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INSTITUTE

Held in the
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Forty-Ninth Annual

DATE GROWERS' INSTITUTE

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VOLUME 49

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PRESERVATION OF MOISTURIZED DATES

A. DOUGLAS KING, JR. and HAROLD R. BOLIN¹

Dates have been recognized for a long time as an energy-rich food throughout many countries of the world. Normally, dates are quite dry (21% moisture) when harvested and seldom create a microbial spoilage problem. However, if they are marketed at this moisture level, the consumer complains about their hardness. The texture of dates can be softened by hydrating them to 24% moisture or higher, depending upon the amount of sugar inversion that has occurred; at this moisture level, yeast spoilage of the dates can be a problem (10).

Microbial spoilage in dates, as well as in prunes and figs, has generally been controlled in the past by an epoxide treatment. The epoxides have a high degree of killing power and produce essentially a sterile product (3, 9, 12). However, in the past few years the use of epoxides on dried fruits has been prohibited, and the major prune and fig processors have used potassium sorbate for treating high moisture fruits (6). Industry representatives recently have reported date spoilage to be their greatest problem. The present study was undertaken to find antimicrobial agents to retard microbial spoilage of processed dates.

MATERIALS AND METHODS

Pitted or unpitted Deglet Noor dates were divided into two batches and their moisture level adjusted to 22% or 27-30% with steam. The 22% moisture dates were used in dip treatments, which resulted in final moisture of 28-30%. The high moisture level provided conditions in which spoilage was certain to occur.

Dates were inoculated with approximately equal numbers of the osmophilic date spoilage yeasts, *Saccharomyces rouxii* and *Saccharomyces mellis*. An inoculum of 3×10^3 yeasts/gram was added to the dates and incubated for 24 hours at 25°C before antimicrobial treatment.

The 22% moisture dates were dipped in one of the following antimicrobial solutions: 2% and 5% potassium sorbate, 0.5 to 2% propyl-p-hydroxy benzoate, 2% methyl-p-hydroxy benzoate, 2% heptyl-2-hydroxy benzoate, 2% 3-acetyl-4-hydroxy coumarin, 2% octylgallate, 2% obtusastylene (p-cinnamylphenol), 2% calcium propionate, and then packaged in plastic bags. The inoculated 27 to 30% moisture dates were packaged and then the respective antimicrobial agents (peracetic acid, ethyl formate, diethyl pyrocarbonate, propylene oxide, isomaltol and ethyl sorbate) were added before sealing. For gaseous treatment (methyl bromide, nitrous oxide), the plastic bags were sealed and the gas injected through a needle into the bag; then the hole was sealed over.

The packages containing 160 g of treated dates were all stored in a 74°F incubator.

Samples were removed periodically during the 90 day testing period to determine if any microbial growth had occurred. Microbial growth was determined in two ways: by visual examination and by measuring the changes in bag volume by water displacement.

Potassium sorbate was determined by the method of Nury and Bolin (5), and moisture was determined by the AOAC method (1).

RESULTS AND DISCUSSION

Propylene oxide provided good microbial protection at the 0.3% level (V/W). However, an objectionable odor was noticed upon opening the packages treated with this chemical. This off-odor was present regardless of the purity of the commercial propylene oxide. Taste was not affected, and the odor disappeared when the dates were aerated.

Potassium sorbate has been used successfully and extensively for treating other high moisture dried fruits, such as prunes

and figs, by spraying or dipping in a 2% solution (6). However, this same dip did not keep yeast from growing on dates during extended storage (Table 1). This difference in effectiveness is due to a higher pH in dates than in either prunes or figs.

Taste threshold for sorbate varies with the dried fruit. In prunes about 600 to 700 ppm can be detected. A state panel evaluation of date paste indicated that a significant percentage of panel members could not detect potassium sorbate addition at 4800 ppm. However, sensitivity to sorbate varied considerably, with a few panel members consistently able to detect sorbate in dates at 1000 ppm. At higher levels, tasters indicated that it produced a slight burning effect or a reduction in flavor. Moreover, the sorbate was not distributed uniformly throughout dates. Pitted dates dipped in 2% potassium sorbate solution contained 900 ppm sorbate in the whole date, but concentration in the skin was 1250 ppm while the flesh contained 690 ppm. Therefore, sorbate can be used to give antimicrobial control for dates if the concentration is kept in the range where no taste difference occurs and if dates have a low moisture level or a low level of contamination.

Table 1. Storage life of pitted and unpitted dates dipped in 2 and 5% sorbate solution

Whole or Pitted	Potassium sorbate dip (%)	Storage time — days					
		5	10	15	25	40	90
W	0	+++					
W	2	—	—	+	+++		
W	5	—	—	—	—	++	+++
P	0	+++					
P	2	—	—	—	+	++	+++
P	5	—	—	—	—	—	—

— = No spoilage.

+, ++, +++ = 1/3, 2/3, and all spoiled.

and figs, by spraying or dipping in a 2% solution (6). However, this same dip did not keep yeast from growing on dates during extended storage (Table 1). This difference in effectiveness is due to a higher pH in dates than in either prunes or figs.

Taste threshold for sorbate varies with the dried fruit. In prunes about 600 to 700 ppm can be detected. A state panel evaluation

(Table 2). Even a 0.5% dip provided protection for about a month, and a 2% dip inhibited microbial growth for the full 90-day storage period. However, off-odor and off-flavor were imparted to the dates at the higher treatment level. Similar results were obtained with the methyl ester but the heptyl ester was ineffective. Both these esters had an off odor and flavor also. Therefore, it appears that these hydroxy-

Table 2. Storage life of unpitted dates dipped in different concentrations of propyl-p-hydroxy-benzoate solutions

Propyl-p-hydroxy-benzoate (%)	Storage time — days					
	5	10	15	25	40	90
0	+++					
0.5	—	—	+	+++		
1.0	—	—	—	—	++	++
2.0	—	—	—	—	—	—

— = No spoilage.

+, ++, +++ = 1/3, 2/3, and all spoiled.

¹Western Regional Research Laboratory, Agricultural Research Service, U. S. Department of Agriculture, Berkeley, California 94710

Table 3. Antimicrobial protection provided by various treatments on pitted dates

Treatment	Storage time — days						
	5	10	15	25	40	60	90
Calcium propionate	+	+++					
Diethylpyrocarbonate	+++						
Ethyl sorbate	—	—	—	—	—	—	—
Heptyl-p-hydroxybenzoate	—	++					
Isomaltol (vapor)	—	—	+	+++			
Nitrous oxide	+++						
3-Acetyl, 4-hydroxycoumarin	—	+	++	+++			
Obtusastyrone	—	—	+	+++			
Octyggallate	—	+	++	+++			

— = No spoilage.

+, ++, +++ = 1/3, 2/3, and all spoiled.

benzoates cannot by themselves be useful in inhibiting microbial growth on high moisture dates.

Numerous other treatments were tried with marginal success (Table 3). When 20 cc of nitrous oxide and 4 cc of diethyl pyrocarbonate were added to 160 g of dates, no protection was obtained, also 2% dips in 3-acetyl-4-hydroxy coumarin and octyggallate were ineffective as were dips in 2% solutions of obtusastyrone, calcium propionate, or isomaltol vapor treatment. Heating was also investigated but caused the dates

to darken noticeably, particularly as the moisture level of the dates increased.

Ethyl sorbate, a derivative of sorbate acid, added to packaged dates and heated for a few minutes to vaporize the ethyl sorbate prevented spoilage (Table 3). Full protection was realized at a 0.3% treatment level; however, dates treated at this level also had an objectionable odor that would limit the usefulness of this treatment.

Methyl bromide was investigated for its effectiveness against microorganisms on fruits. When dates were treated with up to

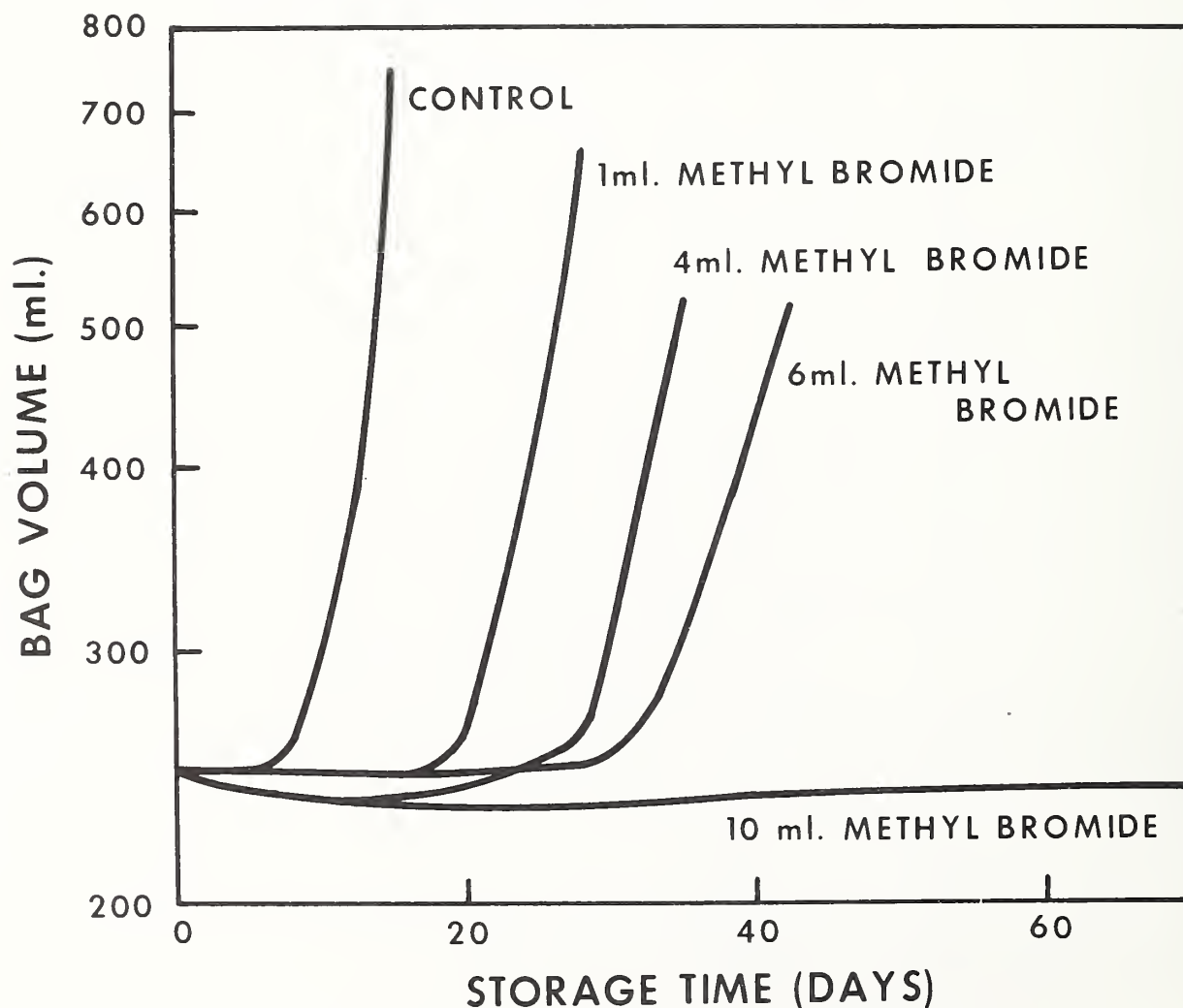
10 ml of gas per package (Fig. 1), only the 10 ml gas injection gave complete protection. However, this treatment imparted an off-odor to the dates.

Studies were undertaken to determine if combination treatments would result in an increased antimicrobial activity at chemical concentration below the odor and flavor thresholds. Potassium sorbate (2% dip) was used because it did not impart a noticeable flavor change at this level, with various other chemicals. When methyl bromide was added, microbial protection was obtained with as little as 0.5 ml of gas (Table 4).

Table 4. The effect of sorbate and/or methyl bromide on microbial growth of high moisture dates

Methyl bromide ml	Storage life — days	
	Water dip	2% Potassium sorbate dip
0	6	25
0.5	20	> 90
1.0	20	> 90
2.0	20	> 90
4.0	20	> 90
6.0	28	> 90
10.0	50	> 90

Fig. 1. Gas production from microbial spoilage on dates treated with methyl bromide



At this low treatment level, taste panel evaluation indicated that there were no detectable odor or flavor changes in the fruit. Therefore, this appears to be a practical method of microbial control for high moisture dates. Methyl bromide has been cleared by FDA for use on dates if the residual bromide is below 100 ppm, calculated as inorganic bromide. If all the methyl bromide injected (using 1 ml of the gas) were absorbed by the dates the maximum possible would be 21 ppm. However, methyl bromide passes readily through packaging materials, so the amount absorbed by the dates should only be a fraction of the amount injected into the headspace (8). No methyl bromide could be detected by gas chromatographic analysis when bag headspace was analyzed two weeks after adding 2 ml. This loss of methyl bromide also illustrates the advantage of using a combination treatment. The methyl bromide reduces the original microbial count and then dissipates, while the potassium sorbate remains to provide lasting protection.

Peracetic acid alone also exhibited antimicrobial properties, but its effectiveness was greatly increased when the dates were first dipped in a 2% potassium sorbate solution (Table 5). However, even at the 0.2 peracetic acid treatment level a certain tartness and vinegar odor were given to the dates.

Ethyl formate was found to inhibit microbial growth when added to dates at 3 ml per lb. (Table 6). However, at this concentration it also imparted an objectionable odor. When the dates were first dipped in a sorbate solution, ethyl formate treatment could be reduced to 1.5 ml per lb., but even at this level it could be detected in the treated dates.

The best overall method for prevention of yeast spoilage in this series of experiments was the combination sorbate-methyl bromide treatment. Other procedures provided protection but imparted a flavor or odor change to the moisturized dates. The effectiveness of antimicrobial agents is increased as the moisture content of the fruit is decreased (2). This knowledge, plus the information as to the effectiveness of various chemical or chemical treatment combinations, can be used to produce packaged succulent dates free from microbial spoilage.

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The authors thank J. Schade, DFA of California Collaborator, for his helpful suggestions; D. G. Guadagni for his taste panel evaluations; and A. E. Stafford for sorbate analysis. The authors also wish to express thanks to the California Date Growers Association for the dates used in these experiments.

Table 5 The effect of sorbate and/or peracetic acid on microbial growth on high moisture dates

Peracetic acid %	Storage life — days			
	26% Final moisture		30% Final moisture	
	Water dip	Potassium sorbate 2% dip	Water dip	Potassium sorbate 2% dip
0	5	20	5	20
0.1	9	35	9	25
0.2	10	> 90	9	> 90
0.4	15	> 90	11	> 90
0.6	> 90	> 90	11	> 90

Table 6. The effect of sorbate and/or ethyl formate on microbial growth on high moisture dates

Ethyl formate ml/lb	Storage life — days			
	26% Final moisture		30% Final moisture	
	Water dip	Potassium sorbate 2% dip	Water dip	Potassium sorbate 2% dip
0	6	21	5	21
0.4	10	38	8	22
1.5	> 90	> 90	14	> 90
3.0	> 90	> 90	> 90	> 90

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HYDROLYTIC ENZYMES IN DATES AND THEIR APPLICATION IN THE SOFTENING OF TOUGH DATES AND SUGAR WALL DATES

SHIN HASEGAWA, DORA C. SMOLENSKY and V. P. MAIER¹

INTRODUCTION

Texture is perhaps the most important factor which determines the quality of dates. The formation of tough, dry dates and sugar wall dates has been recognized for many years in the date industry. However, the mechanisms involved in these undesirable processes are not clearly understood.

Because of the decreasing supply of farm labor, the date industry, like other agricultural industries, has of necessity turned to increasing mechanization of harvesting practices. This mechanical harvesting has led to other problems in sorting and processing of dates prior to packing. In general a broader range of fruit materials reaches the processing plant. This phenomenon results in not only more labor in the process-

ing plant to grade the fruit but also it is more difficult to make a good sort regardless of the number of sorters. As a result of the great changes in nature of the fruit, a better understanding of the properties of and factors leading to the formation of tough, dry dates and sugar wall dates, was needed.

Research on dates has been mainly concerned with chemical and physical analyses related to the quality and ripening of the fruit. Studies on the biochemistry of dates have been very limited. Consequently, the new research program at the Pasadena laboratory was initiated in 1967 with the aim of obtaining knowledge of biochemical factors involved in the ripening of the fruit and also to determine what factors lead to the formation of low quality fruit.

This paper summarizes the results of biochemical research on dates obtained at the Pasadena laboratory. The presence of three hydrolytic enzymes, polygalacturonase, cellulase and invertase in the fruit, and the onset and development of these enzymes related to ripening of the fruit will be discussed. Also discussed is the possible commercial application of these hydrolytic enzymes in the softening of low quality fruit.

POLYGALACTURONASE AND CELLULOSE

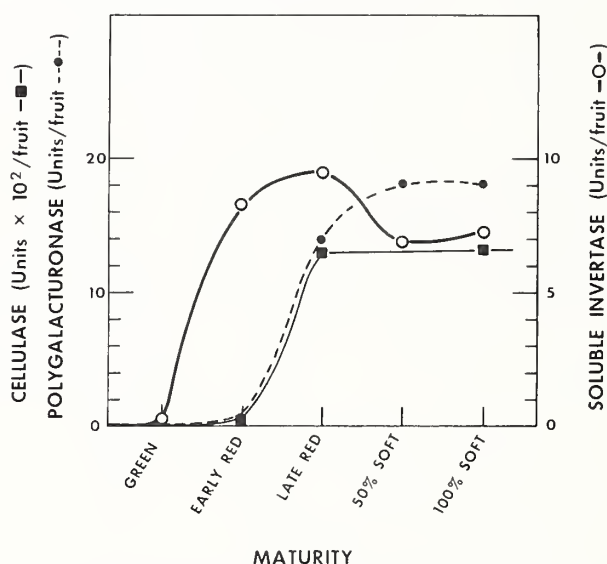
We demonstrated for the first time the presence of two hydrolytic enzymes in mature dates which are generally believed to play an important role in the softening of plant tissues. They are polygalacturonase (4) and cellulase (6).

Pectic substances are widespread in the plant kingdom, and function as an intercellular substance which binds adjacent cells together. Thus, solubilization or breakdown of this cementing material results in a decrease in firmness of the tissues. Polygalacturonase, which catalyzes the hydrolysis of α 1,4 glycosidic linkage of pectic substances, is one of those enzymes which cause alteration of pectic substances.

¹Fruit and Vegetable Chemistry Laboratory, Agricultural Research Service, U. S. Department of Agriculture, 263 South Chester Avenue, Pasadena, California 91106.

Mature dates possess a relatively high activity of polygalacturonase (4). The fruit contains 0.9-1.3 units of activity per one gram of the fresh tissue. However, no activity is present in the tissue of green immature fruit. As shown in figure 1, polygalacturonase activity begins to develop as maturity progresses. The greatest increase in activity occurs between the early red and late red stages, and reaches its maximum when the fruit commences softening.

Fig. 1. Changes in activity of polygalacturonase, cellulase and soluble invertase during maturation of Deglet Noor dates.



It has been also suggested that cellulase, in addition to pectic enzymes, contributes to softening of plant tissues. This enzyme catalyzes the hydrolysis of the β 1,4 glycosidic linkage of celluloses which are considered to be the structural polysaccharides in plant tissues. Mature dates contain cellulase activity. Its activity appears to be, however, much less than those of polygalacturonase and invertase when compared on an unit basis (6). Like polygalacturonase, cellulase activity, which is absent in the green stage, begins to develop during the early stages of ripening (Fig. 1). There is a sharp increase in activity when the fruit ripens from the early red to late red stages, and its activity remains fairly constant throughout the softening stages.

INVERTASE

Dates contain very high concentrations of sugars, mainly sucrose, glucose and fructose. It appears that the degree of sucrose inversion is closely correlated to the textural quality of the fruit. Soft, high grade dates have a ratio of reducing to total sugar content higher than that of tough, low grade fruit (3, 7, 8).

As early as 1911, Vinson (9) reported invertase activity in dates. In earlier research at the Pasadena laboratory Maier and Metzler (7) made an intensive study of effects of temperature, moisture and added invertase upon the rate of sucrose inversion, and also on the quality of the fruit. As a result, they developed the inversion process which brought about an increase in invert sugar, a more uniform color and improved invert flavor.

Our recent study shows that invertase activity is both in soluble and insoluble fractions of mature dates (5). In immature fruit substantial activity is found only in the insoluble form. The enzyme appears to be bound to insoluble fractions in such a manner that the enzyme is accessible to substrate, and carries out its catalytic function. The soluble invertase, which is virtually absent at the green stage, increases in activity sharply as the fruit matures from the green to the early red stages. The development of soluble invertase activity is slightly earlier than that of polygalacturonase and cellulase (Fig. 1). The insoluble invertase, on the other hand, gradually decreases as the soluble invertase increases. The insoluble invertase appears to be converted to the soluble form as maturity progresses. This interpretation is supported by the fact that both soluble and insoluble invertases have similar substrate specificity, attacking sucrose, raffinose and melezitose in a similar manner (5).

ENZYME ACTIVITY AND RIPENING

The dramatic onset and development of polygalacturonase, cellulase and soluble invertase activity appear to be very well correlated with maturation and ripening of the fruit based on data obtained by chemical, histological and physical analyses. Coggins *et al* (2) reported the occurrence of cell wall dissolution during the pre-harvested softening of dates. They showed also that a sudden increase in breakdown products of cell wall polymers occurred during the late red stage (1). These results strongly suggest that hydrolytic enzymes are involved in the breakdown of cell wall material.

Another important finding was that tough, low quality grades of dates are deficient in enzyme activity (Table 1). Polygalacturonase activity in No. 2 dry dates is only 50% of that of the natural grade, suggesting that the formation of low quality fruit comes about as a result of arrested development. What causes arrested development is not clearly understood. It might be due to the lack of moisture supply through the stems to maintain moisture levels sufficient to

Table 1.

Comparison of Polygalacturonase and Invertase Activity
in the Different Grades of Deglet Noor Dates

Grades	Invertase (units/fruit)			Polygalacturonase (units/fruit)
	Insoluble	Soluble	Total	
Sugar Wall	3.37	4.34	7.71	-
Natural	2.27	8.61	10.88	13.2
Waxy	2.19	8.96	11.15	10.5
No. 1 dry	2.00	6.43	8.43	7.7
No. 2 dry	1.50	4.90	6.40	6.2

carry out normal biological functions to complete the ripening process.

Invertase activity, particularly soluble invertase activity in sugar wall dates is considerable lower than that in other grades (Table 1). This explains why the ratio of sucrose to reducing sugars in this type of fruit is much higher than the ratio in other fruit (Table 2). Among dates studied, the sugar wall fruit contains the lowest soluble invertase activity and the highest ratio of sucrose to reducing sugars.

USE OF ENZYMES TO IMPROVE DATE QUALITY

With this new understanding of the enzyme chemistry of dates, we are currently concerned with the control of native hydrolytic enzymes, and the possible application of appropriate outside enzymes during post-harvest treatments to improve the quality of tough, dry dates and sugar wall dates. Although experiments are in their early stages, some encouraging and positive results have been obtained.

Results of studies of the effects of added hydrolytic enzymes on the softening of No. 2 dry dates are shown in Table 3. Dates were cut into halves. One half was sprayed

with water as the control and the other half was sprayed with a 0.1% solution of various hydrolytic enzymes. The final moisture content was approximately 20%. After 4 hours of incubation at room temperature, texture was measured with a Lce-Kramer shear press. Sets of 3 halves were used for each run and 10 determinations were made for each experiment. Average values show that all the samples given enzyme treatment are softer than the control, but statistical analyses indicate that only cellulase gave a highly significant effect on the softening of date tissues. Studies of effects of cellulase on the softening of the fruit during long term incubation under various conditions are underway.

The application of added invertase in the softening process of sugar wall dates appears to improve the quality of this type of fruit significantly. The results are summarized in figures 2 and 3. Dates were vacuum hydrated to approximately 23% with water or with a 0.5% aqueous invertase solution. The incubation was carried out in a closed chamber at room temperature. Samples were withdrawn after 2, 7, and 12 days of incubation and analyzed for their sucrose and reducing sugar contents by the method

previously described (5). As shown in figure 2, there was a significant difference in sucrose inversion between the control and invertase treated samples. Ratios of sucrose to reducing sugars in the enzyme treated sample decreased from 1.8 to 0.6 after 12 days of incubation, whereas those of the control decreased to only 1.1.

The effect was more dramatically demonstrated with dates of lower moisture levels (Fig. 3). Dates were cut into halves;

Table 3.

Effects of Hydrolytic Enzymes on
the Softening of Tough Dates

Treatments	Texture (cm ² /g fruit)*	
	Control (H ₂ O)	Enzyme
Cellulase (Sigma)	0.0941	0.0799 ^a
Cellulase (Rohm & Haas)	0.0909	0.0851 ^c
Cellulase (<i>Asp. niger</i>)	0.107	0.0922 ^b
Pectinase (Rohm & Haas)	0.0999	0.0935
Pectinase (Calbiochem)	0.0722	0.0690
Rhozyme (Rohm & Haas)	0.0786	0.0761
Invertase (Mann)	0.0844	0.0799

* Shear press values. Average of 10 replicates

^a .01 probability level

^b .05 probability level

^c .10 probability level

one half sprayed with water and the other half sprayed with 0.5% invertase. The final moisture content was approximately 14%. Dates were incubated in a manner similar to the previous experiment. No obvious sucrose inversion was observed in the control whereas the ratio of sucrose to reducing sugar in the invertase treated samples decreased from 2.0 to 1.1. In addition to inversion of sucrose the invertase treated samples developed a soft texture and shining appearance while the control remained tough and dry.

These results strongly suggest that the proper application of added cellulase in the softening process of tough, low quality dates, and invertase for sugar wall dates

Table 2.

Comparison of Sugar Composition in the
Different Grades of Deglet Noor Dates

Grades	Sugars (g/10 g fruit)		
	Sucrose	Reducing	Sucrose/reducing
Sugar Wall	5.16	2.45	2.11
Natural	4.24	3.76	1.12
Waxy	4.56	3.27	1.39
No. 1 dry	4.84	2.98	1.62
No. 2 dry	4.96	3.08	1.61

Fig. 2. Effects of added invertase (by vacuum infiltration)
on the sucrose infiltration of sugar wall
dates, final moisture content 23%.

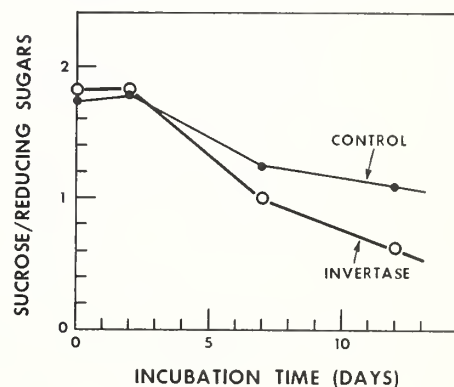
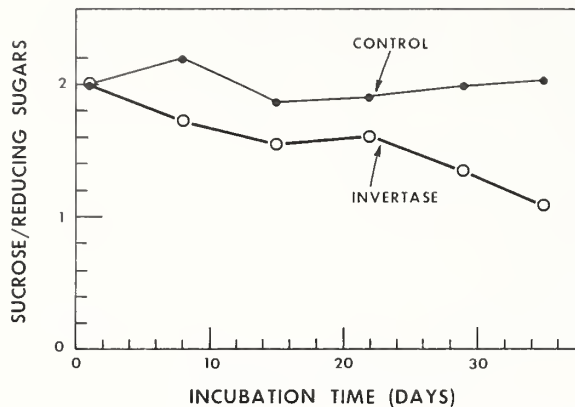


Fig. 3. Effects of added invertase (by spray treatment) on the sucrose inversion of sugar wall dates, final moisture content 14%.



can improve the quality of these types of fruit significantly. Both vacuum infiltration and spraying appears to be feasible methods for the commercial application of the enzymes to the fruit. Based on these observations, further investigations on the possible use of these and other enzymes in the quality improvement of low grade fruit are underway.

SUMMARY

Mature Deglet Noor dates possess three hydrolytic enzymes, cellulase, polygalacturonase and invertase. The onset and development of these enzymes are very well correlated with the ripening of the fruit. The formation of sugar wall dates appears to be due to deficiency of invertase activity. Tough, dry dates possess less hydrolytic enzyme activity than higher quality fruit. Added cellulase is effective in the softening of tough, dry dates, and added invertase is effective in improving the quality of sugar wall dates.

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Reference to a company or product name does not imply approval or recommendation of the product by the U. S. Department of Agriculture to the exclusion of others that may be suitable.

THE USE OF MALATHION FOR THE CONTROL OF DATE INSECTS

L. E. VINCENT and D. L. LINDGREN¹

In 1945, a year of abnormally high humidity and rainfall, one-half to three-fourths of the date crop was lost because of molds, souring, and beetle infestation. The date industry requested the University of California to investigate the possibilities of controlling insects that infest dates. At this time and the immediate years following many new insecticides were available for testing.

Methods such as flooding by irrigation, chemical treatment of the soil to control immature forms, spraying of the date overlay, use of treated paper covers and netting, and garden sanitation were evaluated. All these measures helped to reduce the beetle population in the bunches but were not economically effective, suggesting that the insects were moving into the bunches from surrounding areas wherever decaying vegetable matter occurred and it was concluded that the best approach to controlling these insects would be one or more properly timed applications of insecticidal dusts to the date bunches.

Laboratory screening of available insecticides was conducted to determine their initial and residual toxicity to date-infesting insects. Elimination of materials that had no effect on date insects in the laboratory tests narrowed the scope of the field work to those compounds showing the most promise — lindane, chlordane, aldrin, dieldrin, heptachlor, parathion, and malathion. Under field conditions, all of these materials, applied as dusts to each bunch, were effective in controlling the insect population in dates. Chlordane and lindane dusts imparted an off-flavor to the dates and consequently their experimental use was discontinued.

Due to its low mammalian toxicity, malathion was chosen for extensive field experiments and results indicated that treated bunches remained free of insects for a period of at least three weeks following treatment. No effect on flavor was detected by the use of malathion dusts.

The Insecticide Division, U. S. Department of Agriculture accepted the following label claim for prepared dust: "For control of dried fruit beetle on dates, apply 4% or 5% malathion dust. A thorough coverage should be applied to each cluster. Make no application on dates within 21 days of first picking." Following this acceptance, malathion was first used in 1953 on a commercial basis. Malathion is the only insecticide registered for use on dates having an accepted tolerance of 8 ppm. Results of experimental work and commercially applied treatments in date gardens have established that a 5% malathion dust applied three weeks prior to the first picking is effective in reducing or eliminating nitidulid beetle and phycitid moth populations, provided the dust is thoroughly applied to the entire bunch.

The use of insecticidal dusts, particularly those toxic to warmblooded animals may create a residue problem. In 1952 residues of malathion were determined on washed and unwashed Deglet Noor dates that had been dusted with a 5% malathion dust.

¹Staff Research Associate and Entomologist, respectively, Department of Entomology, University of California, Riverside, California 92502.

Table 1. Results of chemical analyses of Deglet Noor dates dusted with 5% malathion²

Number of weeks after treatment	Malathion (parts per million)	
	Unwashed fruit	Washed fruit
Control	0	0
1	3.25	0.67
2	1.96	0.47
3	1.25	0.47
4	1.06	0.58

²Malathion analyses conducted by Drs. F. A. Gunther and W. E. Westlake, Dept. of Entomology, University of California at Riverside.

Results are given in Table 1. It can be seen that two weeks after application the malathion residue in unwashed dates was slightly less than 2 parts per million and that on washed dates was less than 1 ppm, both of which are well below the official tolerance of 8 ppm.

Mechanization in California of all phases of date culture, particularly in harvesting, has increased at a rapid rate the past few years. About 80% of the 1968 crop of Deglet Noor dates was harvested by cutting mature bunches from the palms and mechanically shaking the fruit into bulk bins. A delayed harvest may require successive dustings at regular intervals if the insect population remains active. It is our observation that beetle activity is usually on the decline after the first to the middle of October, when the weather begins to cool.

In order to evaluate the residues that might be obtained with repeated malathion dustings, a series of experiments was conducted in which Deglet Noor bunches were dusted once, twice, and three times at 3-week intervals between each dusting. A 5% malathion dust was used and was applied by means of a hand duster. Results are given in Table 2. Those bunches receiving one dust application (9/8/71) and two dust applications (9/8/71 and 9/29/71) had malathion residues of less than 8 ppm one week following the final dust application. Those bunches receiving three dust applications (9/8/71, 9/29/71, and 10/20/

71) had residues of less than 8 ppm three weeks following the final dust application. It should be noted that these results were obtained on field-run fruit that had not been processed. Table 1 indicates that processing reduces the residue considerably.

The problem of resistance of insects to chemical pesticides has been recognized for many years. Many species of insects have exhibited tolerance to malathion, including houseflies, mosquitoes, cockroaches, mites, and several species of stored product insects.

Elmer (1967) reported that tests were conducted to determine the resistance level of the nitidulid beetles and phycitid moths to malathion. Populations of the corn sap beetle and the Indian meal moth were collected from 8 different localities in the Coachella Valley, and were exposed to various dosages of malathion for various periods. He concluded that there was no evidence that resistance to malathion occurred in these local populations.

All the experience of resistance under field conditions has emphasized the great importance of detecting and characterizing resistance as soon as possible. A natural reaction to chemical control failure is to repeat the treatment if not also to increase the dosage rates. The dangers of this in terms of increased contamination, undesirable food residues, and possible infringement of residue tolerances are obvious. Moreover, if failure is due to resistance, continued use of the same chemical may be a waste of time and money.

Control failure may be due to factors other than resistance, such as unusual climatic conditions, faulty application, unsuitable formulations, etc. In any event the correct course of action must depend upon their identification. The only way that the emergence of a resistant population can be reliably detected is by the regular collection of field samples of the pest and a quantitative estimate of their response or "susceptibility" to the chemical or chemicals in use.

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Table 2. Results of chemical analyses of unwashed Deglet Noor dates dusted with 5% malathion. Dusts applied at 3-week intervals.²

Weeks after final dust application	Malathion (ppm)		
	1 dust 9/8/71	2 dusts 9/8-9/29/71	3 dusts 9/8-9/29-10/20/71
Initial	9.2	—	12.6
1	2.6	4.9	12.3
2	0.7	3.8	9.7
3	1.1	2.4	3.3
4	0.5	2.4	3.2
5	1.0	3.6	4.0
6	0.5	2.0	4.1

²Malathion analyses conducted by Drs. F. A. Gunther and W. E. Westlake, Dept. of Entomology, University of California at Riverside.

1971 MEDJOOL DATE PRODUCTION IN BARD, CALIFORNIA

EVELYN BERRYMAN

The Medjool date seems to thrive in the desert along the banks of the Colorado River. Growers are enthusiastic about it and are pleased with the fine quality of fruit produced in the Bard area of the Imperial Valley.

There are several reasons favoring production in this area. All of Bard has an underground moving water table from 4 to 8 feet deep and because of this, there are places where 2 acre-feet of irrigation water are all that are required annually. This water is used to wet the upper soil surface and to help decompose the manure applied as fertilizer. Organic fertilizers are used and are obtainable from local dairies and feedlots. This year some growers used small amounts of chicken manure. Irrigation water costs \$15.00 per acre per year, and this allows 5 acre-feet per year on heavy soil or 8 acre-feet on sandy soil. The top soil varies from sand to silty loam to clay.

The first Medjool date garden was planted in the Bard area in 1944 by Stanley Dillman and Al Collins. These early pioneers in the date industry had other varieties in production, including Khadrawy, Zahidi, Saïdy, Halawys and others. They were so pleased with the size, texture and flavor of the Medjool date that every offshoot available was planted in their garden. Bard's original source of Medjools was 24 offshoots received from Indio in 1944 by Dillman and Al Collins. Twenty-two of the original palms are alive today. At present, there are approximately 350 acres of Medjool dates planted and an anticipated 100 acres are to be planted in the future. Some of the dates are interplanted with citrus. Not all the present plantings are producing palms, but the total pounds of Medjools harvested in Bard in 1971 was 269,500 lbs. These were delivered to four local packing houses: Imperial Date Garden, Bard Valley Date Garden, Lyle Date Garden and Berryman Farms.

When they are planted, the date offshoots are wrapped in burlap to protect them from the sun. The usual spacing of the palms is 30 feet by 30 feet. The offshoots survive well in sandy soil but many have died in heavy soils. Therefore, the owners of some gardens find it desirable to start them in nurseries where things such as the water can be regulated. Some growers use ferbam, a fungicide, to control fungi on young offshoots.

Weather conditions, of course, determine the time of pollination. This year a warm spring caused pollination to start in January. Workers then began to gather the male pollen, and as soon as a worker found a cracked spathe on a female palm he cut the sheath off and applied a little pollen. The strands were then tied together with string with a simple slip knot. This string keeps the strands from tangling with the leaves and can be seen from the base of the palm as evidence of the bunches that have been pollinated.

Mr. Dillman, the pioneer date grower, used the system of 13 bunches per palm. This system would not overwork the palm and would permit annual production. It includes removing the center of the date bunch, leaving an outer rim of about 25 strands. After the fruit has started to size, a worker removes crowded fruit and leaves about 13 dates to a strand. However, some gardeners in the area do not thin so carefully, and they usually produce more fruit of a smaller size.

In August when the dates have become heavy enough to pull down to their natural place, wire rings of about 8 inches in diameter are placed in the center of the bunches. As the fruit begins to ripen, the bunches are covered with a cotton bag. When measured flat, the bag is 33x58 inches, and the top 27 inches is waterproofed. These bags are placed over the

bunches and the top tied with string. The cotton bag is economical in that it can be used several times. A bag costs about 75c. Bags keep insects, birds and light rain from damaging the crop. The bunches are not sprayed or dusted for insects or diseases.

This past season, Bard had about 2 inches of rain in early August and 2 inches in October. Usually this presents big problems. However, cool winds followed the rain and dried the bags. Crop damage was minimal, maybe a 5% loss. It would have been a different story if the humidity had remained high or more rain would have drifted in from storms over the Gulf. Usually, the September and October weather is hot and dry and excellent for harvesting the dates.

Each palm produces about 160 lbs. of fruit. The dates are marketed to many outlets throughout the United States and Canada. The demand for top quality dates exceeds the supply.

Dates grown in the Bard area are not hydrated. They are picked and taken to packing houses that dry them just enough to insure good moisture content and yet dry enough to ship and store satisfactorily.

There is the usual fumigation by using methyl bromide. However, the organic customers are asking for and getting dates which have not been fumigated. This means taking top quality fruit, free from insects, directly to storage at zero degrees. Any bug that may find its way into a box going to such storage, will be frozen.

From this report you can see that our date culture has not changed much from that worked out by Stanley Dillman. Our growers believe that the Medjool date, with its fabulous flavor and other fine features, grows best along the banks of the Colorado River, using organic fertilizer and the protection of cotton bags, and that upon harvesting quick freezing is the means of preserving freshness.

HISTORY OF DATE CULTURE AND RESEARCH IN ARIZONA¹

R. H. HILGEMAN²

Date culture and research in Arizona can conveniently be divided into three periods.³ (1) 1890 to 1920 was a period of research and development with a gradual increase in commercial interest in the palm. (2) From 1920 to 1950 the commercial development of the industry occurred. Nearly all gardens were planted between 1920 and 1932. Between 1930 and 1950 packing and marketing the fruit predominated. (3) Beginning in 1950 activity declined rapidly. Reduced yields caused by freezes and excess precipitation, increasing costs of production and urbanization, which often provided a profitable exit from the business, all contributed to the demise of most of the industry by 1960.

PERIOD 1 — 1890 - 1920

OFFSHOOT IMPORTATION AND RESEARCH. The introduction of the date into Arizona is usually credited to the founders of the Catholic missions in Mexico, Arizona and California, who apparently planted date seeds prior to 1739 in lower California. The pioneers who settled in southwest Arizona after the Civil War grew date palms from seed in irrigated areas near Tucson, Phoenix and Yuma. Variations between seedlings promoted requests from growers to the U. S. Department of Agriculture to import offshoots from the Middle East in the 1880's.

The development of a date industry became a major project of the recently activated (1889) University of Arizona, Agricultural Experiment Station. The cooperation of the U. S. Department of Agriculture was obtained and offshoot importations from Egypt, Algeria, Arabia and Baluchistan (Iraq) were initiated.

The first palms were imported in 1890 through U. S. Consuls in Algeria, Egypt and Arabia. Ten palms were planted at the University of Arizona Agricultural Experiment Farm, located near Phoenix on Grand Avenue at about 23rd Avenue. Thirteen palms, which all died, were sent to H. W. Blaisdell at Yuma. Of the 10 palms sent to Phoenix one died, six were males and three were females (1898). It was evident that seedling dates were sent instead of the varieties named.

In 1898, Professor J. W. Touney, Botanist at the Arizona Experiment Station, published "The Date Palm." Descriptions of certain seedling varieties were given along with a report on seedlings investigated. Only 40% were considered edible and 10% acceptable for commercial use. Comparisons were made of weather records in Arizona with those in date growing areas in North Africa. Temperature conditions appeared to be sufficiently similar to suggest that date culture would be successful in Arizona and California desert areas. However, he noted the difference in summer precipitation in the Southwestern desert but concluded, "It is not likely that the time of rainfall in the regions compared will have any marked effect . . ."

Major importations of offshoots by the U. S. D. A. were initiated in 1900 and continued until 1908. Up to 1904, all were planted on a 15 acre tract at Rural Road and Baseline Road which was donated by J. J. Jungerman. The fact that the soil was saline was considered an advantage at the time. The final report on the importations in 1908 showed 234 varieties and 1,000 offshoots were imported, of which 491 offshoots representing 135 varieties were growing. R. W. Nixon subsequently determined a number of these were identical varieties imported under different names.

During the importation period many methods of treatment were tried. The initial major shipment of 405 offshoots supervised by W. T. Swingle left Africa on June 11, 1900 and was received on July 17. Offshoots were fumigated with hydrocyanic gas and then planted July 22 to 26. All were irrigated daily with water carried in barrels on a wagon. A straw mulch was applied around each offshoot. Seventy-one percent were growing vigorously the following summer.

In subsequent shipments other methods of handling were generally less successful: choosing small 2 kg. (5 lb.) offshoots (26% survival), growing one year in nurseries before shipment, rooting in tubs before shipment, shipping late and planting in November (2% survival). Wrapping of offshoots with moist peat moss was inconclusive. About equal survival was obtained from unwrapped offshoots. Fumigation did not damage the palms.

In 1905-06 much information was obtained. The initial planting at Yuma was made on May 20, 1905. Because of breaks in the new canal, irrigations of offshoots varied from 3 to 17 days. Survival of 74% of 154 planted indicated that daily watering was not required. At Tempe, heavy irrigation of surrounding farms raised the water table to near the surface, where it apparently remained until the mid 20's. The palms were reported as "prospering" under these conditions. *Parlatoria scale* (*Parlatoria blanchardii*) was discovered. On vigorous palms, A. J. Shamblyn pruned the leaves back to the trunk and burned the leaf bases with a gasoline torch without killing any of them. This procedure had been followed in the two previous years

at the Phoenix Experimental Farm. The first good crop of dates estimated at 4,000 lbs. was set but almost all fruit was eaten by rats. Gophers became a problem. Over 100 offshoots were cut and distributed in Arizona, California and Texas. Vinson classified dates into cane sugar and invert sugar varieties and reported on invertase in the date. Professor J. J. Thornber reported tannin accumulated in large sub-epidermal cells.

From 1908 to 1912 the Experiment Station did not have a horticulturist but Director Robert H. Forbes, A. E. Vinson, chemist, and Professor G. F. Freeman, plant breeder, took a keen interest in date problems (1911). To determine varietal differences in souring, they found that the dry matter was 54-60% at the onset of ripening in dates that soured, whereas those resistant to souring contained 60 to 70% dry matter. The unevenness of ripening was emphasized by attempts to ripen entire bunches with nitrous oxide which showed from 25 to 50% of the fruit in October were too green to ripen. Pasteurization of dates at 65-70°C for 2-3 hours caused nitidulid beetles to leave the fruit and die. Freeman (1911) found curing dates at 45-48°C (113-118°F) produced the best fruit. Higher temperatures caused darkening and a syrupy fruit. It was suggested that fruit could be sold as "fresh dates" at a premium over imported dates.

Of 491 date seedlings planted in 1902, none that had fruited were worthy of propagation. The most promising imported varieties were Braim (Barhi) Khadrawy, Kustawy, Nesheem, Nazel el Bacha, Maktoom, and Hayany (Birket el Haggi) which was considered best. The Deglet Noor ripened very late but part of the crop was saved by heat ripening.

The total salt content of the water taken from a hole in the Tempe orchard in ppm was 3,434 with 1,084 Na, 1,600 Cl and 44 No₃. Similar values were reported for water in an adjacent drainage canal in 1920. By 1920, the soil surface was covered with salt. Only a few salt tolerant weeds grew and no irrigations or cultivations had been made for many years.

In 1915, F. H. Simmons, foreman at the Date Orchard from 1905 to 1917, cured dates in three operations: 1) Exposed to CO₂ gas under slight pressure for 18 to 24 hours; 2) heated on ventilated trays at 45 to 49°C (113-120°F) for 48 to 60 hours; 3) pasteurized at 65°C (145°F) for 2-4 hours, according to the size of the fruit. To determine marketing possibilities, soft type dates were packed in 454g (1 lb.) baskets and shipped all over the United States for immediate consumption as fresh fruit. Semi-dry Deglet Noor fruit was packed in tin boxes and sold as non-perishable. Best grade fruit sold at 25 to 35¢ per 454g and lowest bulk grade 10¢. Yield and income in 1915, a year of perfect weather, were compared with those in 1916 when a heavy September rain severely damaged the crop. A few results are of interest (Table 1).

¹University of Arizona, Agricultural Experiment Station Journal, Article No. 1943, except for the list of major plantings.

²Horticulturist, University of Arizona, Tempe, Arizona.

³In compiling this history, the writer has relied chiefly upon information published in the Annual Reports and publications of the Agricultural Experiment Station. Other information has come from personal experiences during the period after 1930 and from information supplied by John O'Dell, County Agricultural Agent between 1931 and 1963, Bernard Benson and former date growers: Jay Hyde, Lawrence Mehren and Frank Brophy.

Table 1. Yield and Income from certain varieties

Variety a	Number of Palms	1915			1916		Income dollars
		Yield Kg	pounds	dollars	Yield Kg	pounds	
Hayany	17	1,760	3,875	686	818	1,803	327
Rhars	159	6,040	13,300	2,198	1,750	3,860	590
Deglet Noor	40	1,100	2,430	725	158	348	103
Kustawy	6	24	53	10	133	292	56
Bent Kebala	1	46	107	15	98	216	39

^aNote by author. Palms were in severe alternate bearing. Apparently Hayany, Rhars and Deglet Noor were "on crop" in 1915 and Kustawy and Bent Kebala in 1916.

Dates were also stored at 2 to 3°C (36-38°F) in October in commercial cold storage rooms. All dates except Hayany stored well until mid-January, but became moldy during the next 10 months.

The 1917 season was apparently favorable and 1918 ideal but heavy rainfall resulted in a complete failure of the Rhars and Deglet Noor crop in 1919. Hayany, Bent Kabala, and Tadalá were reported as highly tolerant to rainfall throughout the 1908 to 1919 period. It was recognized during this period that rainfall was the most severe hazard to growing dates in Arizona and that considerable differences in tolerance to rain existed between varieties. In the light of later information, it is difficult to understand the high rain tolerance of the Hayany. One marked difference in culture occurred. Prior to about 1924 the high water table maintained a constant water supply to the palms. Between 1930 and 1942, when the data reported in Table 2 were obtained, the water table had been lowered to about 15 m (50 ft.), so that irrigation was required at about three week intervals in the summer.

Between 1908 and 1918, 536 offshoots were distributed to 134 growers and 98 percent had died. Consequently, in about 1920 emphasis was placed on propagation. Numerous experiments by F. J. Crider (1926) and D. W. Albert (1926) demonstrated that offshoots with well developed roots obtained by mounding soil around the palm base or placing a box with soil around high offshoots, resulted in much higher survival (91%) than obtained from poorly rooted ones (40%). Also, higher survival occurred with large offshoots above 9 kg (20 lbs.) and superior survival when they were wrapped with burlap and grown in the open as compared with a shaded house. As a result, recommendations were made to plant large rooted offshoots wrapped with burlap.

In May 1920, defoliation and torching of all palms to control *Parlatoria* scale delayed further fruiting until 1922. The defoliation caused a constriction in the palm trunks and in a few instances offshoots developed immediately above this point. A 30 foot tall Rhars palm failed to resume growth but a whorl of offshoots was produced. A box of soil placed around the offshoots induced roots on offshoots and trunk. The trunk was cut below the offshoots and planted. All offshoots grew and the mother palm resumed growth. This is the only instance I know of where this was accomplished (43rd Annual Report).

Margaret C. Smith reported that dates contained: from 480 to 700 vitamin A unit, 177 to 275 vitamin B₁ units and 230 to 350 vitamin B₂ units (1931).

PERIOD 2 — 1920 - 1950

COMMERCIAL DEVELOPMENT, PRODUCTION AND MARKETING. Beginning in about 1920 and extending through about 1934, small gardens were planted in all parts of the Salt River Valley basin. In the Yuma area, the University of Arizona introduction garden was sold to Edwin Hansberger and fruited commercially. Several small gardens were planted.

Because an outstanding variety had not been established, each grower selected varieties he considered to be superior. With the exception of Hayany, most of the offshoots were initially obtained from Coachella Valley growers. Offshoots from these palms then were sold locally. Col. Dale Bumstead was the most enthusiastic grower in urging the planting of dates. As a result of his activities from 80 to 100 acres of Maktoom, Iteema, Dayri, Khalasa and Sayer varieties were planted.

In 1919, Robert Metzler discovered a seedling palm at a home in Phoenix. He purchased it, and in cooperation with his partner, Frank Brophy, planted it and 10 offshoots at the Phoenix Date Company garden. Subsequently, Frank Brophy became the sole owner and propagated all offshoots at this garden which was renamed Sphinx Date Garden. This is the only seedling variety of sufficient merit to be extensively propagated. Offshoots were exported to Israel in about 1954 and palms are now in production near Lake Tiberias.

An accurate census of named imported varieties was never taken. Records of offshoots planted were compiled by the Arizona Commission of Agriculture and Horticulture through inspection of offshoots for *Parlatoria* scale. By 1934, when inspections ceased because of eradication of the insect, these records showed a total of 356 acres of imported varieties in the Salt River Valley, 93 acres at Yuma and 51 acres in other parts of the State (48 palms per acre). Of this acreage, 3% was 14 years old or older, 9% from 10 to 14 years, 56% from 5 to 9 years, and 32% from 1 to 4 years. Only a few gardens comprising not more than 40 acres were planted thereafter. In 1946, commercial gardens were estimated at 300 acres. The acreage of principal varieties

was estimated as follows Deglet Noor 25; Halawy 22; Hayany 49; Iteema 23; Khadrawy 94; Maktoom 22; Zahidi 21. Among other varieties there were 2 to 4 acres of each of the following: Dayri, Khalasa, Kustawy, Sayer, Tazizoot and Thoori — a total of 44 acres (1946). It appears to the writer that these estimates were low.

Processing, packing and marketing fruit became the major activity after 1930. Typical procedures were as follows: soft dates were picked by hand when ½ ripe to fully ripe; fumigated overnight with methyl bromide or ethylene oxide mixed with carbon dioxide; cleaned on damp towels and graded for maturity with injured and sour fruit discarded; cured on ventilated trays at temperatures of 40 to 46°C (104 to 115°F) for 2 to 4 days; packed in different types of containers and stored at 0 to -18°C (32 to 0°F) until marketed. A few growers pasteurized dates after curing at 65°C for 2 hours. Dry dates were hydrated during the curing process. From 1945 to 1950, Halawy and Zahidi fruit was frequently left on the palms until all of it was ripe; it was harvested by either shaking or cutting the bunches.

Two attempts at cooperative packing and marketing were tried. The first one was started in 1930 by six or eight growers from the Tempe, Mesa area with T. L. Stapley as manager. Fruit from the University of Arizona Experimental Date Garden was marketed with this organization in 1930 and 1931. Low volume and high overhead costs caused its failure in 1932. In 1945, the Arizona Cooperative Date Producers Association was formed by Tempe, Mesa and Chandler growers under the management of Chester Munson. A packing house with a capacity of about 400,000 lbs. of fruit was built at Chandler. Modern equipment was installed. Attempts were made to ship fruit to Midwestern states, with distribution through local wholesale outlets. Other marketing programs were also followed. This cooperative failed in 1948.

Almost every grower, eventually built his own packing house and developed his own sales program. In many instances the grower's wife played a prominent part in curing, packing and selling the fruit.

The most successful marketing programs relied on direct sales to consumers by mail order or local retail sales. A good example is the Gilliland Groves. Between 1935 and 1940, they packed very high quality dates in attractive boxes with the object of competing with fancy candies. A large mail order business was developed. In several years sales were greater than their production. When packing houses were located on main roads, and attractive sales rooms and parking facilities provided, direct sale to consumers was highly successful. Many grower-packers followed a combination of these methods. Other growers relied more on sales to local retail grocery stores and specialty shops.

During World War II, sugar was rationed, imports were limited, date prices were not controlled and very high prices were obtained for fruit. Under this impetus new packing facilities were built, care of gardens improved and a real effort was made to establish an industry.

The total production of fruit was never established. One of the best growers, who packed and sold his own fruit between 1945 and 1955, reported to me that he sold from

25,000 to 30,000 pounds of fruit each year from his 10 acre garden of Khadrawy dates. Because of sales of low grade fruit, it appears possible that during the peak production and price period during World War II from 1.5 to 2.0 million pounds of fruit were sold. During the five years before and after this period the probable production ranged between .5 and 1.0 million pounds. 1939 and 1951 must be excluded because rains destroyed almost all of the crop.

An Arizona Date Institute was formed in 1947 to stimulate interest in date culture, improve the quality of fruit produced and processed, increase the demand for fresh dates and reactivate a date research program. Annual meetings and numerous committee meetings were held. A bulletin on date processing was published (1948) and a state law enacted setting forth minimum quality standards. A list of most of the members with the officers the first year is as follows: Lawrence Mehren (President), W. J. Van Spankeren (Vice President), John T. McChestney (Secretary), Mrs. W. P. Sherrill (Treasurer), Harry Palmer (Director), John Steward (Director), Mulford Winsor (Director), G. L. McLane (Director), Jay Hyde, Leo Crosson, Col. James Wood, Clarence Pruett, L. G. De Villiers, A. B. Yanez, Joseph M. Greer, Rex Seaton, Leonard Redden, Mrs. Denison Ketchel, Mrs. Betty B. Stein, Joe Hammond, Edgar LeBaron, Francis Baker, Richard T. Allen, U. B. Newman, Chester A. Munson, Wayne Wright, Edwin L. Hansberger, Reid's Rancho Palos Verdes, and Tal Wi Wi Ranch. With the decline of the date industry the organization was officially terminated at the annual meeting in June 1954.

RESEARCH PROGRAMS. In 1930, a small laboratory-office was built at the Date Garden at Tempe. D. W. Albert was transferred from Tucson to the Station and was in charge of research until his death in 1936. I had been his assistant and continued his work with J. G. Smith as my assistant until it was decided to discontinue date research in 1941. During this period, date research occupied about 30% of our time.

From 1930 to 1942, the response of a selected group of varieties to weather conditions and pathological infections was reported each year. A summary of the data from the annual reports is shown in Table 2. Of the most rain-tolerant varieties, the Kustawy was small and blistered; the Khadrawy in the late years developed a pre-ripening shrivel which interfered with normal sugar accumulation; after 1936 the Maktoom discolored, some pre-ripening shrivel occurred and a water-soaked condition developed in part of the fruit in some years. The Tadala was the most satisfactory variety, but few offshoots were available for further propagation. Records show conditions were favorable for very good ripening in 1930, 1934, 1938, 1940 and 1942. An almost complete loss occurred in 1939. In other years rainfall caused losses which varied among varieties, because of the time the rain occurred.

The severe 1937 freeze of -7 to -9°C (19 to 16°F) caused severe to slight injury to fronds (Table 2). At the Experiment Station the crop was thinned to compensate for leaf loss and the number of inflorescences in 1938 was satisfactory. In most commercial gardens thinning was inadequate in 1937 so the number of inflorescences were reduced in 1938.

Table 2. Estimated losses from rainfall between 1930 and 1942 to 14 varieties; maximum freeze damage in 1937; annual losses.

Variety Performance			Yearly Average Loss ^a		
Variety	Rainfall losses ^a %	Freeze Damage ^b %	Year	14 Varieties ^c %	5 Varieties ^d %
Bent (Kebala)	17	—	1930	17	7
Braim (Barhi)	32	90	1931	44	13
Deglet Noor	58	30	1932	—	—
Halawy	38	75	1933	35	20
Hayany	62	40	1934	20	8
Iteema	45	35	1935	37	10
Khadrawy	17	90	1936	35	6
Kustawy	18	35	1937	34	11
Maktoom	25	70	1938	27	10
Rhars	74	90	1939	72	55
Saidy	45	60	1940	22	21
Sayer	10	50	1941	45	28
Tadala	10	—	1942	20	13
Zahidi	29	10			

^aLosses refer to 12 year average values of estimated percentages of dates damaged by splitting and subsequent checking directly caused by rain and subsequent infection with fungus, yeasts and acid forming bacteria that resulted in unmarketable fruit.

^bMaximum amount of damage to fronds from 1937 freezes. Observations in 5 commercial gardens. Minimum losses in warmer areas were about one-half of these values.

^cAverage loss from all 14 varieties in column 1.

^dAverage loss from Khadrawy, Kustawy, Tadala, Sayer and Zahidi.

Other research involved: studies of the development of inflorescences and seasonal growth of leaves; fruit growth and ripening in relation to accumulated heat (1933); sugar accumulation in fruit and the relation of moisture content of dates to storage life (1938). A general bulletin, "Date Growing in Arizona," was published (1934). No formal reports were made on the development of a rain resistant bag with a ventilated hood which Dillman and Collins modified and found satisfactory at their garden at Bard, California. Attempts to reduce rain damage by spraying fruit with different compounds were unsuccessful.

At the request of the Arizona Date Institute, date research was reactivated in 1948. G. C. Sharples was assigned full time to the project from 1948 to 1952 and I was project leader. Emphasis was placed on reducing rainfall loss. Studies were made of microorganisms present during curing (1953) and of the effect of low soil water on rain injury to Maktoom fruit during the late kalal and early ripening stages (1957). Final reports were also made on date palm growth and anatomy (1951) and the differentiation of buds, inflorescences and offshoots (1954). The project was terminated in 1955.

About 25 Medjool palms were planted by Harry Palmer at his date garden near Mesa in 1946. About 70 offshoots from these palms were subsequently planted. This garden is in commercial production at present. In 1952, 25 offshoots were planted near the property line at the Citrus Experiment Station in Tempe. Limited observations indicate the variety is better adapted to Salt River Valley conditions than most of the varieties previously tested. I rate the variety as moderately to highly rain tolerant, but infection with *alternaria* fungus has occurred during prolonged rainfall and high humidity conditions.

PERIOD 3 — 1950 - 1960

TERMINATION OF THE COMMERCIAL INDUSTRY. After World War II, because date imports were resumed and sugar was again available, the demand for fresh dates lessened and prices were reduced. However, the leaders of the industry continued good care of gardens and several new packing facilities were constructed. Mail order business was emphasized and markets developed.

The weather, however, was adverse. Severe freezes in January 1949 and January 1950 caused more extensive defoliation than occurred in 1937, and the crop was severely reduced. In August 1951, extraordinarily heavy rainfall of 141 to 186 mm (5.56 to 7.32 inches) induced a complete crop loss. Spotted heavy rainfall caused slight to heavy crop damage in 1949 and 1953 and discouraged growers. The current leaders of the industry, who were business oriented, quickly discovered that heavy financial losses could be associated with date growing.

During this period, a rapid migration of people to the Phoenix area caused rapid expansion of urbanization, so that gardens could be profitably sold. This discouraged further production. As this situation accelerated, practically all gardens were either subdivided by 1960 or palms sold to subdividers. Other contributing factors were death or retirement of growers and increased labor costs.

It is somewhat ironic that the large, well adapted Medjool date and the application of late summer water stress, which markedly reduced losses, when rainfall was not excessive, did not evolve until the industry was almost extinct. Who knows what might have happened if we had known as much in 1920 as we know now?

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DATE OUTLOOK -- 1972

JOSEPH C. GENSKE¹

This subject — date outlook — would imply that we are about to look into a crystal ball and foretell the future. But that is not the real intent of this talk. The future of an industry does not start with a crystal ball. It starts with the members knowing where they are in a given point in time, realizing the nature of the market forces about them, and making plans to meet them. Normally, it is the plans and efforts of the members of an industry that become the industry's future. Consequently, the main thing we can do here this morning is look at what and where we are and what is happening around us.

Let us begin by asking, "What is today's date industry?"

World-wide, it is an annual production of close to four billion pounds. Three exporting countries — Iraq, Iran and Algeria — produce about half of the world's dates. Most of the remainder is produced in the other countries of North Africa and Asia Minor.

What happens to all this production? Well, close to 80 percent of it remains in the primary production area. About 10 percent moves eastward to India, China and Japan. Six to seven percent moves northward to Europe and the USSR. About three percent moves to the rest of the world, and this includes the one percent coming to the United States. In recent years, the U. S. imports of dates have been less than 30 million pounds. However, in the current year they are slightly over 30 million.

With so much of the vast production of the Arabic regions remaining there, it is understandable that dates are often referred to as a staple food of the area. The term "staple" means, of course, a principal or chief item found in the markets of a country. It is understandable, too, that with these ample quantities of dates, a picture is formed of the Arab populace subsisting practically on dates alone. In fact, however, they must and do supplement their dates with bread and rice and other foods richer in the essential proteins of life.

It is a fact, too, that dates are far from being one of the biggest crops of the world. Coffee production exceeds that of dates, and dry bean production is three times greater. Rice production exceeds date production by 100 times, and potato production exceeds dates by 120 times. And wheat, that giant of the world, exceeds date production by 1,500 times — staying just a jump ahead of a rising world corn production.

There is also in the world a substantial production of human beings. This has been accompanied by a spreading sense of sanitation and of knowledge about how to combat disease and how to feed the body properly. Fewer are dying at birth and more are living beyond their middle years. In other words, it is not just the birth rate alone that is increasing the numbers of the human race.

And as we might expect, the multiplication of the human being causes a pressure on the available supply of food. Where there is the added factor of greater affluence — more money to spend — the pressure is severe on quality or luxury foods.

A case in point is the world deficit of meat. Today, more people in Chile have the incomes to afford meat, and so the meat and livestock of the country have practically disappeared. We have long heard that there is an awfully lot of coffee in Brazil, but recent reports indicate there is very little meat. And travelers arriving in Argentina with visions of a wonderful steak in one of the great beef producing countries of the world, discover to their horror that they have arrived in a meatless week. Meat is served only every other week. This is to conserve supplies and provide meat for export — to earn money. And meat is scarce in Central Europe, in Arabia, in Africa. The message has gotten to Australia — historic producer of wheat and wool — and the switch is on to beef and feed grains.

In some of the less affluent countries of the world, the wealth of the country has long been concentrated in a few hands. This meant that 10 percent of the populace could buy the food it wanted; 90 percent could not. But things are changing. All nations are experiencing an increase in wealth and also a wider distribution of wealth among the people. Meat scarcity is only one of the consequences. When a nation moves from money in the hands of 10 percent of its people to money in the hands of 20 percent, the market — the demand for meat, for specialty items, for luxury food — has suddenly doubled.

Now, there is pressure on the agricultural producers, the handlers, the distributors, the importers — to respond. But in some countries this is impossible. The political situation makes it impossible, particularly when the new demand wants not only volume — it wants quality. To make quality available calls for education of producers and handlers, more market organization, regulations firmly applied and above all a funding of these efforts. But the funding means taking money away from other "priorities." It is easier to say, "Tell the United States and Europe that this is what we have to sell and this is what they have to buy."

While we do have reports of foreign date producing countries preparing to capture and export quality fruit, we know that this will only skim the cream off the top. If our reading is correct, their efforts do not mean a significant growth in the volumes they will export. It is not even clear that past volumes will be maintained.

Yet, various markets are interested in obtaining greater quantities of specialty items, to add variety to the diet, to satisfy the craving for a treat, a snack or an unusual cooking ingredient.

And with that, let us look at the California Date Industry.

The 1971-72 production, the latest crop in this valley, was 39 million pounds and consisted of 35.8 million pounds of Deglet Noor dates, 1.7 million of Zahidi, and 1.5 million of all others. In order of descending volume, the "all other" consisted of Khadrawy, Barhi, Medjool, Halawy, Honey, Empress, and a quantity of seedling dates.

This is an average-size crop and shows very little change from what the industry was producing, on the average, 15 years ago. Handler receipts were then about 39.5 million pounds of which about 3.0 million pounds were culls.

Now at this point, someone can rise up and say, "Wait a minute! You got this all wrong. Fifteen years ago, average production was over 45 million pounds. The State Statistician and the U. S. Department of Agriculture say so!"

And that is right. That is what these respective parties have in their printed reports. They have included all production of value to the grower, and 15 years ago that meant 6 million pounds of field culls sold to a buyer who is still buying culls from us today. However, supplies of farm labor and harvesting methods have changed. Now, most field culls are not picked up. Our current tabulation indicates less than 450,000 pounds will be picked up and delivered from the 1971-72 crop. At the same time, more culls are finding their way into the bins of handlers and hence into handler receipts and this amounts to about a million pounds more than 15 years ago.

Thus handlers currently have about 35 million marketable pounds to sell of all varieties, and this is almost the same as it was 15 years ago. Occasionally, down through the years, big crops were produced and handler receipts went up. But the record clearly shows that sales did not increase by the same amount. The thing that increased was the carryout into the following year. On a few occasions, this was partly relieved by purchases of the U. S. Department of Agriculture.

In this respect, the date industry's sales problems are matched by other specialty crops. Changing consumption patterns and competition from other foods, both natural and manufactured, have hindered expansion of consumption and made it difficult to maintain existing levels. We see this throughout the dried fruit industries and especially in an item like prunes. And what has happened to the family nut bowl — once the main outlet for California walnut industry? It has disappeared from the homes of the older families and the younger families do not bother with it.

In comparison, the California Date Industry has fared rather well. The records seem to say that its United States sales of whole and pitted dates, of all varieties, never did exceed 25 million pounds. The balance was ground into products, or exported or carried over in hopes of a shorter crop in the following year.

In recent years there has been a loss of domestic sales of whole and pitted dates.

¹Manager, California Date Administrative Committee.

From 15 years ago, this may be as much as 2.5 million pounds. It is even more true of imported dates, where the U. S. sales are off by over 12 million pounds. This is based on their earlier sales averaging about 42 million pounds and their recent sales falling below 30 million.

It could be argued that the imported dates were packaged and sold mostly for home cooking instead of for eating out-of-hand, that there has been a decline in home cooking, and this explains their loss. However, we also know that the quality control of this industry's marketing order program has caused like quality control to be placed on imports and neither Iraq nor Iran harvest and handle many of their dates in a manner permitting them to meet the standards. Thus, a combination of factors have caused the reduced sales of imported dates.

The attractive packaging of much of the California crop, the ease with which they can be eaten out-of-hand, and the fact that about 60 percent are now offered as pitted dates, may all have helped in maintaining the package sales of this industry. In addition, there has been better grading. Top quality has gone into packages, a slightly lesser quality is being exported and the poorer dates are going to products. In rounded percentages, we can say that 45 percent is being sold domestically in packages, 25 percent is being exported and 20 percent is going to products. The balance of 10 percent represents the culls.

Recently we took a closer look at one aspect of domestic date consumption — that which occurs due to roadside sales right here in the Valley. A rather good poundage of Deglet Noor naturals, Medjool, Barhi and other succulent varieties are being sold at prices ranging from 50 cents to \$1.50 per pound. They look and taste and are priced like a fine confection. I am certain the purchaser has no visions of using them for cooking.

Total roadside sales, of all qualities and types, including mail order, are about 1.5 million pounds of which the Deglet Noor is number one with about 700,000 pounds and the Medjool is number two with close to 300,000 pounds. For the latter to be that large, a substantial poundage must be brought in from the Bard area of Imperial County.

There is another point of view on the declining domestic consumption and that is in the expression, "Who cares?" Total sales into export outlets have climbed from a small percentage of the crop to where they are taking 25 percent. This is in the form of

eight million pounds to Europe, a million and a half to Latin America, 300,000 to 400,000 pounds to Australia and another 200,000 to a number of other destinations. Much of this poundage is new business of the last two years and some of it gives indications of further growth in the future, providing that this industry can find the necessary supplies.

The handlers and the California Date Administrative Committee are to be commended for their efforts in fitting all usable dates into one or another market outlet. They have used a combination of grade and volume regulations to do this and recently established a Utility grade — slightly better than culls — to make a necessary addition to product supplies. Incidentally, the Committee has also approved the shipment of Utility grade to Mexico to foster a growing products and confectionery industry in that country. Mexico often applies a licensing system to control the number of persons who may import a commodity and develop its consumption, and this was applied to dates as of March 28, 1972. We presume that at least one substantial buyer has such a license.

Now that I have developed a picture which shows California as a producer for the world, with the U. S. market as merely its number one outlet, and that the industry is facing a supply shortage, I hesitate to look at any other aspect of the demand for dates. Yet I find one quite interesting and believe that it should be noted. It is the image of a date which people seem to have.

A pound of dates has no more calories than a loaf of white bread. Dates are not among the high calorie items. They are a medium calorie item. A pound of dates has less than half the calories of a pound of shelled, roasted peanuts or of a pound of potato chips. If your girl friend is becoming a bit too plump, give her dates instead of chocolate candies and reduce the calories she consumes by one-third.

Moreover, dates will give her some nutritional elements she needs. Dates are about two percent protein and two percent roughage, very little fat, good amounts of iron and potassium, some calcium and other minerals, very little sodium, fair amounts of Vitamin A and B and good amounts of energy-giving invert sugar. They are an excellent item to lend variety to our main diet of lettuce, bread, potatoes, and McDonald hamburgers.

Unfortunately, I cannot now tell you whether dates are a "natural" food or give

you the details on how to assure that they are "organically grown." No official definition of either prevails within the Food and Drug Administration or the Department of Agriculture. But this may be resolved within the coming months. As some of you know, a suit has been filed in Los Angeles against three supermarket chains, five suppliers and two independent retail outlets, seeking an injunction against labeling foods with such terms when, it is alleged, they differ in no significant manner from ordinary products.

It has always been assumed, of course, that an item was organically grown if there had been no use of man-made fertilizers, fungicides, herbicides or pesticides. In other words, nothing was used but water, rich soil, and natural fertilizers. In either event, if the man-made items were or were not used, the plant proceeded to create, by an act of nature, a consumable product. As long as that was marketed in the basic form in which it was harvested, I had always assumed that it was a natural food. Let us hope that we will know soon whether it may be or may not be so classified.

And finally, how will the grower benefit in the picture that is here being painted of the California Date Industry? Plagued with his labor problems and his rising costs, what can he expect in returns for dates?

To answer that, let us look at what tends to happen when supplies become tight and then even become scarce relative to the demand. The first thing that disappears within an industry is the tendency of handlers to get business by cutting prices. They get past the point where they keep a wide margin between the price they pay growers and their case-goods price. If the case-goods price stays firm — because every handler can sell all that he has — the handler does not need as wide a margin. He really can pay the grower a little better price.

Then comes the next step. Some handlers find that they could use more supply. They go out to look for it. They find that they are not alone. If they want supply, they have to compete for it, offer more money. This goes on for a time. Supplies get shorter; offers get a little better. And then, if all is going according to the short supply-strengthening demand formula, the handlers realize that they will have to raise their case-goods prices to get the money they need to pay the better prices to the growers.

And the good news: I heard — just this week — that an increase in the case-goods prices is in the mill.

A STUDY OF NEW AND RAPID METHODS FOR THE VEGETATIVE PROPAGATION OF DATE PALMS¹

O. REUVENI, Y. ADATO AND HANNAH LILIEN-KIPNIS

Date palms are vegetatively propagated by offshoots which are produced by young palms. The rapid propagation of a particular palm, as well as propagation from a mature specimen, is impossible due to the limited number of offshoots produced and the fact that offshoot production is limited to a certain period in the palm's life span. The development of propagation methods which overcome these obstacles is particularly important in cases where propagation of a new cultivar is desired and only one selected specimen exists.

A solution to this problem was sought in work conducted at The Volcani Center with the aid of a grant from the U. S. Department of Agriculture². Although the final objective was not achieved, we should like to report a number of methods which were investigated, developed and tested. Three separate lines of work were conducted concurrently: rejuvenation of mature palms, rooting of small offshoots, and testing the possibilities of using tissue culture techniques for propagation. We shall report each section of the work separately for the sake of convenience.

REJUVENATION OF MATURE PALMS

The life span of a palm tree is divided into two distinct developmental phases. The first stage is the vegetative one in which no inflorescences develop, and the buds forming in the leaf axils develop into offshoots. In the second stage, the generative one, the buds develop into inflorescences and offshoot production ceases. An intermediate stage exists in which both offshoots and inflorescences are formed. There are, however, a number of cultivars which produce offshoots after the reproductive stage has begun. Occasionally, one or more offshoots are found on a mature tree, but the reason for this unusual temporary production of offshoots is not known. This fact attracted date growers throughout the long history of this fascinating tree, and it seems that rejuvenating mature palms was attempted every now and again. The reports of success found in the literature must be regarded with some doubt since no systematic work was devoted to this subject. A well-planned experiment with date palms involves not only technical difficulties, but work with a large number of palms makes the cost prohibitive.

In approaching the subject of testing possibilities of rejuvenation, the following thoughts guided our operations. Since axillary buds differentiate into either offshoots or inflorescences at a very early stage of development, and those which do not differentiate die (9), any treatment planned to affect these buds must be given to the

crown of the palm where the buds are formed. The treatments we attempted may be divided into two main groups. The first, chemical treatments with substances which (a) have been reported to inhibit flowering in other plants (3), (b) have reverted other plants to their juvenile phase (27), or (c) are known as either growth promoters or growth inhibitors. The latter were used in an attempt to upset the metabolic equilibrium of the plant and to induce offshoot production. There is evidence in the literature that mature palms produce offshoots after a shock treatment like torching. However, this does not occur in all cases (8). The second group of treatments involved procedures which were also based on the idea of giving the palm a shock, or upsetting its metabolism. We tried rooting mature palms below the crown with the intention of sawing the trunk just below any new roots which may have formed. On replanting the palm with its very short trunk, the crown would be brought much closer to the roots. It is a well-known fact that juvenility of tissues or organs decreases the further they are from the roots. This is also true of date palms, since offshoots are generally produced only at the base of the trunk, close to the roots. Furthermore, the rooting potential of the trunk seems to be confined to its basal region. Only a few roots formed on the upper parts of a palm when it was replanted so that the whole trunk was covered with soil, and this occurred only after a number of years in the ground (21).

MATERIALS AND METHODS

To avoid chance results, each treatment was given to at least two palms. As already mentioned, the number of palms which could be used for these experiments was limited owing to their high cost. Since no information concerning the physiology of bud differentiation in date palms was available, we treated the palms at different times of the year in the hope that one of them would be at the "right" time. The treatments were as follows:

a) Chemical Treatments

Ten-year-old Zahidi palms were treated with DAPC, 2,4,5-TP or GA. Four palms were used for each treatment, which started in March 1967. Spray treatments were given at a rate of 25 liters per tree and included a wetting agent (0.05% Tween 20). The method of treatment was as follows:

Diethyl aminoethanol phosphate trihydroxychloride (DAPC). Palms were sprayed monthly with 0.2% DAPC from March 1967 to March 1968. Another three sprays were given in July, September and November of 1968.

2,4,5-TP. Palms were sprayed monthly with 100 ppm 2,4,5-TP from March 1967 to March 1968. Another three sprays at a concentration of 300 ppm were given in July, August and September of 1968.

Gibberellin. Monthly sprays of 100 ppm gibberellic acid (GA₃ — Berelex, ICI) were

given from March 1967 to March 1968. Two more sprays, at a concentration of 200 ppm, were given in September and November of 1968. In another treatment with GA₃, 500 ml of a 10,000 ppm solution were poured into the crown of the same palms in April 1969 and in January and April 1970. In September 1970, three leaves on each palm were infused (see section on rooting of small offshoots for details of infusion) with 1 liter of a 1500 ppm solution of GA₃. The same trees were infused in May 1971 with solutions of GA₄ + 7. Four leaves on each tree were each infused with 1 liter of 2500 ppm GA₄ + 7.

Alar. Four twelve-year-old Hayani palms were sprayed with 25 liter of 2500 or 5000 ppm Alar (together with 0.02% Triton B as wetting agent) in November 1968, and in January and March of 1969.

2,4-dinitrophenol (DNP). Four mature seedlings of unknown age were sprayed in November 1968 and in January and April 1969 with 100 ppm DNP (+ either 0.02% Triton B or 0.02% Tween 20 as wetting agent).

Ethephon was sprayed as DNP, at a concentration of 1200 ppm.

Reglone was sprayed as DNP, at a concentration of 250 ppm.

Kinetin — see following section in leaf removal treatment.

b) Other Treatments

Leaf removal. Leaves were carefully cut close to the trunk, their bases and fibers were removed and the trunk was exposed. In August 1966 all leaves except for the youngest four or five were removed from two seedling palms. The remaining four or five leaves were shortened to 20 cm. Two more trunks were similarly exposed but the ten youngest leaves were left. On another two palms, leaves were removed as above, *i. e.*, the ten youngest leaves were left, and 1 liter of 100 ppm kinetin was poured into the crown. All the axillary buds which were exposed by leaf removal were destroyed.

Air layering. In our early attempts at air layering we tried exposing the trunk as close as possible to the crown so that, after rooting, the growing point would be as close to the roots as possible. We found that in spite of very careful work, trunk tissue was damaged as the young leaves were being removed and the palms subsequently died. For this reason, we tried air layering somewhat lower on the trunk, leaving 15 leaves. Four ten-year-old Zahidi palms were air-layered in March 1967. The leaves under the air layer were removed from the trunk. In March of every following year all inflorescences and mature leaves were removed from these palms.

Torching. The Zahidi palms which were treated with 2,4,5-TP or DAPC were used for torching. Four pairs of palms were

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torched (each pair included one palm from the 2,4,5-TP and one from the DAPC treatment). One pair was torched five times, in June and October of 1969 and in January, May and June of 1970. A second pair was torched four times starting in October 1969, a third pair three times starting in January 1970, and a fourth pair only twice — in May and June of 1970.

RESULTS AND DISCUSSION

None of the chemical treatments induced the production of offshoots in place of inflorescences. One palm which was sprayed with 2,4,5-TP (and later torched) produced two offshoots in 1970. It is uncertain whether this was a direct result of the treatment, since the other three palms treated with 2,4,5-TP did not respond. A characteristic of the cv. *Zahidi* is the occasional production of offshoots high on the palm. The fact that the palm flowered in addition to producing the two offshoots, indicates that the treatment had no far-reaching effect on axillary bud differentiation. Since it raised the possibility that the concentration of the substances sprayed was too low to be effective or that the substances were not sufficiently absorbed, or that they were not translocated within the plant, we continued trying with higher concentrations of one substance — gibberellin (see *Materials and Methods*), and different methods of application. When this substance was poured into the crown or infused into leaves, a typical GA response was obtained. The trunk elongated more than usual, the leaves were longer and the fruit stalk as well as flower strands of those inflorescences which flowered were elongated. It is interesting to note that the treatment clearly decreased the number of inflorescences produced in the past two years, but it neither stopped flower production completely nor did it induce offshoot production. Infusion should be tried again with much higher concentrations of gibberellin, since it is the method which best ensures absorption and translocation. The fact that inflorescence stalks and flower strands were markedly elongated following infusion of leaves is good evidence for translocation of the substance.

The various treatments tried did not produce the hoped-for results. The careful cutting of leaves which exposed the axillary buds and enabled us to destroy all flower buds in the hope of inducing the differentiation of younger buds into offshoots, was unsuccessful. Furthermore, we later found out that in spite of our precautions, the palms had been damaged and subsequently died. Less drastic cutting of leaves did not kill the trees but produced no positive results either. Of all the *Zahidi* palms which were air layered, only one rooted. The trunk of this palm was girdled approximately 2 cm below the air layer when the air layer was renewed in 1968. In December 1969, 33 months after the palm was originally air layered, and 21 months after it was girdled, a number of roots were found on the trunk. In March 1970 the other three palms were also girdled at the time the air layer was renewed. At the time of writing this report (April, 1972), these palms had not rooted. The palm which did root was cut beneath the air layer and planted in spring 1971. After its establishment, we shall have to wait and see whether offshoot production will be resumed. It seems to us that rooting of mature trees below the crown should be

tried again. It is worth trying to air-layer the trunk as close as possible to the crown, and to girdle it deeply. Since rooting is so slow, the use of root-promoting substances, e. g. IBA, should be tried by infusion (see section on rooting of offshoots).

Torching did not induce the production of offshoots. Although the palms which were torched four or five times are inhibited in their development and have not flowered, they did not produce offshoots either. The palms torched fewer times have renewed growth and have also started flowering. Hilgeman's report (8) that torched palms produced offshoots must be regarded as chance, since if torching was an efficient method for renewing offshoot production, all the palms in the U.S.A. which were torched to eradicate *Parlatoria* scale should have restarted producing offshoots. Although we have come across offshoots produced high up on palms which were subjected to chance fires, the number of palms which do not produce offshoots following such conditions is far larger. This may be seen in Israeli date gardens situated on the border. The gardens were heavily shelled and many palms were burnt. Those which survived, continue to grow and have not produced offshoots. It seems, therefore, that in cases where torching is effective, the time it is done is of vital importance. The temperature reached during the torching treatment may also play an important role. Constant high temperature in the region of the growing plant should be tried in the hope of inducing differentiation of vegetative buds.

ROOTING OF SMALL OFFSHOOTS

When interest arises in propagating a certain cultivar and a maximal number of offshoots is required, the following method can be employed. Small, low-growing offshoots are separated from the mother palm and are transferred to a nursery. They 'take' well due to the root primordia which developed while the young offshoots were attached to the mother palm. The same cannot be done with high offshoots. They have to be left on the mother palm 2-5 years and sometimes even longer, before they reach a suitable size for rooting in the nursery or air layering. Since new offshoots are produced annually, high offshoots are thinned in commercial practice while still small. Since the rate of rooting of these offshoots is very low in the nursery, they are discarded. It was important to find ways of propagating small, high offshoots after removal from the mother palm since otherwise large quantities of potential propagating material goes to waste.

In the course of our work, a method of mist propagation suitable for date palm offshoots was developed. The mist technique was tried since it has been found very useful with many evergreens. Soon after starting, however, we found that there was a very high mortality rate among the offshoots. Offshoots died from either basal rot, or, destruction of the growing point by rots starting on the foliage and promoted by the very high humidity. After careful investigation we found that these rots were caused by different agents. Much time and effort were therefore devoted to overcoming both "basal rot" and "foliar rot," and various rooting promoters were tried for increasing and hastening the rate of

rooting. Other factors which affect rooting ability and were investigated in this project include: offshoot size, and the composition and temperature of the rooting medium. We also investigated some endogenous factors which affect the rooting ability of offshoots of different size, height and cultivar, (to be reported on elsewhere).

In reviewing the literature concerning this subject, one finds that there is general agreement on a number of points. One of these is that the rate of rooting is low in small offshoots and rises with increasing size up to a point above which greater size has no further advantage. The minimum size ensuring maximum rooting is different for the various cultivars and on this point the results of different workers differ. However, in general it may be said that maximum rooting was obtained from offshoots which weigh over 10 kg (1, 2, 5, 6, 22, 30). It is often difficult to compare the results of different authors, because when expressing offshoot size as weight, they often do not indicate whether the weight refers to offshoots with or without leaves. (Since offshoots are planted in the nursery without leaves, it is reasonable to assume that most people would give offshoot weight after the leaves have been pruned.) In contrast to the failures reported with small offshoots, Bulit and Girard (4) succeeded in rooting very small Deglet Noor offshoots. They do not refer to the growing conditions of the mother palm, and it is therefore impossible to know whether these offshoots were low ones or high ones. Another disadvantage of using offshoot weight as a standard is the fact that size is no indication of physiological or even chronological age. Offshoots from well-looked-after gardens are always heavier than those coming from neglected ones. It seems therefore that comparison of size or weight can be made only if the offshoots come from the same source.

Offshoot rooting is slow and rot-causing pathogens have a chance to attack during the interval between planting and establishment. Date growers know that one way to reduce the occurrence of these rots is by removing offshoots with the tissue connecting it to the mother palm or even with a 'heel' of mother-palm tissue. It is important to remove the offshoot with a smooth cut and care must be taken not to split its base. Disinfection of the cut reduces disease incidence at the base, and Popenoe (24) reports that in Arab countries growers cover the base of the offshoots with tar. Stolar³ and Bulit and Girard (4) tried disinfecting with various fungicides based on copper, iron, or organic tin compounds. Bulit and Girard obtained best results with organic tin and manganese compounds.

Various growth regulators, including indole acetic acid (IAA), naphthalene acetic acid (NAA), indole butyric acid (IBA), 2,4 dichlorophenoxy acetic acid (2,4-D), and 2,4,5 trichlorophenoxy propionic acid (2,4,5-TP), were tried as rooting promoters. These were generally applied as dips or sprays. All these treatments had either a doubtful or no effect (23).

Materials and Methods

The offshoots used for all the experiments to be described below were of the cultivar *Khadrawy*. All developed above ground.

³S. Stolar — unpublished data, 1967.

They were removed from commercial gardens and were rooted under mist in a glasshouse without the removal of leaves (unless otherwise stated). The glasshouse was unheated and temperatures varied with the season. The rooting medium was kept at 25°C (unless otherwise stated). Misting was controlled by a time clock and various times of misting at different intervals were given at different times of the day and at different times of the year.

Offshoot treatments were applied in the following manner: *Foliar sprays*: These were generally applied in the morning and misting was resumed after the spray had dried on the leaves. *Dipping of offshoot base*: Each offshoot was dipped separately. *Application of Shagidol⁴ paste*: Supplementary substances (fungicides, growth regulators) were first dissolved in a small volume of water, the solution was then added to melted Shagidol. After cooling, the resulting paste was applied to the base of the offshoot. *Application of "slurries"*: Substances marketed as wettable powders were mixed with enough water to make a slurry, and this was applied to the offshoot base with a brush. *"Infusion"*: Solutions were infused through the leaves. The two lowest leaves were shortened by approximately one-third. After removal of the distal pinnae, the rachis was dipped into a jar containing the treatment solution. Offshoots absorbed 50-100 cc if treatment was performed after removal from the palm, whereas offshoots still attached to the mother palm absorbed 200-400 cc. Jars containing the solutions were wrapped in polyethylene to prevent dirt from contaminating the solution and to prevent evaporation.

Only some of the experiments conducted will be referred to in the following discussion, and for the sake of convenience they have been numbered 1 to 5. The objectives of each experiment and details of the work were as follows:

EXPERIMENT NO. 1. 416 offshoots taken from 8 to 9-year-old palms (274 from one garden and 142 from another) were planted in March 1967. Their weights ranged from 0.75 to 14.5 kg each. After removal from the palm, the offshoot base was treated with Carbo-etz paste⁵.

Offshoots were planted in a glasshouse divided into four sections, each of which contained eight propagating beds with room for 13 offshoots. Six offshoots were planted in each bed without removal of the lower leaves (untreated) whereas from the remaining seven offshoots, two to six of the lowest leaves were removed close to the offshoot trunk (treated). Great care was taken to mix offshoots of different size in each bed. The 20-cm-deep rooting medium in four beds in each glasshouse section consisted of a 1:1 (v/v) mixture of peat and Kalkar⁶ and that in the other four beds consisted of a 1:1:1 (v/v) mixture of vermiculite, peat and Kalkar. Two beds in

each section were unheated and acted as controls. The remaining three pairs were heated to 20°, 25° and 30°C, respectively. In one section the rooting medium was watered frequently without any misting and the leaves had to be pruned very soon after planting, when signs of wilting were observed. Leaves were cut as is common practice in the open nursery. None of the offshoots died as a result of this leaf pruning. A total of 94 offshoots were planted in this treatment, which will be referred to as "unmisted."

The other three glasshouse sections were planned for high humidity regimes as follows: (a) misting with time clock control, (b) misting with electronic leaf control, and (c) maintaining constant high humidity with the aid of humidifiers. After many technical hitches with the electronic leaves and the discovery that the humidifiers were of insufficient capacity, sections (b) and (c) were converted to misting with timer control, as in section (a). A total of 282 offshoots were planted in these three sections and will be referred to as "mist-sprayed." Offshoots under mist were sprayed at weekly intervals, at first with 1% Bordeaux mixture and later with 0.5% Coprantol⁷; once a month, dry leaves and those infected with *Diplodia* were removed. The resulting cut was sprayed with 2% Coprantol. The following factors were examined in this experiment: offshoot weight, temperature of the rooting medium, propagation with and without mist spray, and treatments which consisted of removing the lower leaves.

EXPERIMENT NO. 2. This trial started on June 1, 1969. Offshoots came from a seven-year-old garden. The rooting medium was a 1:1 (v/v) peat and Kalkar mixture kept at a temperature of 25°C. Offshoots were given a foliar spray of 1% Coprantol once a week and the objective of the experiment was to test the effectiveness of basal-rot-preventive treatments. These included application of Shagidol paste + 10% Fermate, Brestan slurry, Shagidol paste + 1% Caspan, and a Fermate slurry. Root-promoting growth regulators were also tested in this experiment.

EXPERIMENT NO. 3 This trial started on June 1, 1969. The offshoots came from a ten-year-old garden and were rooted in a 1:1 (v/v) mixture of peat and Kalkar kept at 25°C. The base of all offshoots was

treated with Fermate slurry and the objective was to test foliar-rot-preventive treatments. These were given once a week and included sprays of 1% Coprantol, 500 ppm TBZ, 0.3% Vitavax and 0.15% benomyl. After removal from the mother palm, half the offshoots in the experiment were pre-treated by "infusion" with the potassium salt of indole butyric acid (IBA-K).

EXPERIMENT NO. 4. This trial also started in June 1969, with offshoots from a ten-year-old garden. The base of each offshoot was treated with Fermate slurry. Half of the offshoots were sprayed once a week with 1% Coprantol and half of them with 1% Fermate. The objective of the trial was to test the effect which different rooting media have on basal rot incidence. The rooting media tested were a 1:1 peat and Kalkar mixture; a 1:1 peat and quartz sand mixture; pure quartz sand; and volcanic tuff. Half the offshoots in the trial were also given a treatment with CCC (2-chloroethyl trimethylammonium chloride). A 6% solution was infused into the offshoots after removal from the palm.

EXPERIMENT NO. 5 This trial started on January 25, 1970, with offshoots originating in a seven-year-old garden. The objective was to test a combination of treatments which in previous experiments proved effective for the prevention of basal rots and foliar rots. The rooting medium was volcanic tuff, offshoot bases were treated with Fermate slurry and the foliage was sprayed weekly with a systematic fungicide; half the offshoots were treated with 0.15% benomyl and the other half with 0.3% Vitavax. Furthermore, the effect of various growth regulators was tried. Sixteen offshoots were infused three weeks before removal from the palm with 1500 ppm IBA-K, 1000 ppm NAA or 1000 ppm 2,4,5-TP. The soluble sodium salt of NAA and the ethanolamine salt of 2,4,5-TP were used in these treatments. The glasshouse was not whitewashed in this trial and thus the offshoots were illuminated more strongly than in previous experiments.

RESULTS AND DISCUSSION

The results presented here have been arranged and will be discussed according to the problem investigated.

Offshoot size. Results presented in Table 1 confirm the findings of others and

Table 1 The effect of offshoot size on mortality and rooting percentage of Khadrawy date palms 6 and 13 months after planting. (Experiment No. 1)

Offshoot weight (kg)	6 Months after planting			13 Months after planting		
	% rooted	% dead	% unrooted	% rooted	% dead	% unrooted
< 2	9	22	69	14	77	9
2-3.9	23	14	63	31	55	14
4-5.9	25	15	60	35	35	30
6-7.9	22	17	61	29	48	23
8-9.9	38	20	42	50	40	10
10-11.9	47	5	48	53	26	21
<2	—	—	—	14	77	9
*2-7.9	—	—	—	32	46	22
*8-11.9	—	—	—	52	33	15

*Combined groups.

⁴Shagidol: a locally produced tree dressing containing equal quantities of mineral oil, chalk and bees' wax.

⁵Carbo-etz — a plant-safe avenarous carbo-lineum.

⁶Kalkar — locally produced polystyrene flakes.

⁷Coprantol — 3CuO.CuCl₂·4H₂O

Table 2 The effect of rooting-medium temperature and mist spray on percentage rooting and mortality rate of date palm offshoots, 13 months after planting. (Experiment No. 1)

Treatment	Bed Temperature (°C)	Dead Offshoots %	Unrooted Offshoots %	Rooted Offshoots	
				% of total in treatment	% of live offshoots at end of exp.
Mist sprayed	Control (not regulated)	26	24	50	67
	20	44	24	32	57
	25	41	13	46	78
	30	40	24	36	61
	Mean (%)	38	21	41	66
Not misted	Control	77	19	4	17
	20	65	23	12	33
	25	73	15	12	43
	30	69	19	12	38
	Mean (%)	71	19	10	33

show that a correlation exists between offshoot size and rooting rate. The endogenous factors which affect rooting were examined in another part of the project, the results of which will be published later. There we found that the carbohydrate content of large offshoots was greater than that of small ones. Large offshoots were also found

to contain greater quantities of root-promoting substances or smaller quantities of rooting inhibitors. It seems, therefore, that larger offshoots can survive longer because of the larger reserves they contain and they also root faster due to the presence of higher levels of rooting promoters and lower levels of rooting inhibitors.

The highest percentage of offshoots which rooted was found in the 8-12 kg weight group, but even here the percentage was not very high (52%). This was due to the mortality of many offshoots before rooting began. Rooting generally occurred approximately six months after planting. The high mortality rate at early stages of propagation prompted the search for ways of rot prevention and also root hastening treatments.

Rooting medium temperature. Here again we confirmed previously reported findings (24). A heated rooting medium improved rooting and, as may be seen from Table 2, 25°C seems to be the optimum.

Mist propagation. Results presented in Table 2 show that rooting rate under misting was much higher than without it. In some evergreen plants, leaves assist the rooting process and this might also explain the higher rooting percentage of offshoots under mist, since the leaves were not removed.

Pretreatment. In experiment No. 1 a number of the lowest leaves were removed before planting, from all offshoots which came from one garden and only from some offshoots originating from another. Therefore, the results from this experiment could not be analyzed reliably. It appears, however, that early removal of some of the leaves hastened rooting, though the treatment itself often damaged the offshoot base and death ensued as a result. Since no clear-cut increase in rooting rate was found, and the leaf removal treatment involves much careful work, we do not recommend removing the basal leaves on offshoots intended for propagation in the nursery, in contrast to the recommendations made for air layering on the palm.

Table 3 The effect of different fungicidal treatments for basal rot control (FB) and foliar rot control (FF), and the effect of different rooting media (RM) on the mortality rate of Khadrawy date palm offshoots under mist propagation.

Experiment No.	Factor examined	Basal treatment	Foliar treatment	Rooting medium	Months after planting	T R E A T M E N T	No. of offshoots in treatment	No. of offshoots dead	% mortality
2	FB	See treatment column	Weekly spray with 1% coprantol	1:1 (v/v) peat and kalkar	5	Shagidol paste + 10% Fermate	8	6*	75
						Brestan slurry	8	5*	63
						Control	24	14*	58
						Shagidol paste + 1% Caspan	16	7*	44
						Fermate slurry	8	2*	25
3	FF	Fermate slurry	See treatment column	1:1 (v/v) peat and kalkar	8	1% Coprantol once a week	16	15**	94
						500 ppm TBZ once a week	16	11**	69
						0.3% Vitavax once a week	16	7**	44
						0.15% benomyl once a week	16	3**	19
4	RM	Brestan slurry	Weekly spray with 1% coprantol or 1% fermate	See treatment column	5	Peat: quartz sand 1:1 (v/v)	16	5*	31
						Peat: kalkar, 1:1 (v/v)	16	4*	25
						Quartz sand	16	3*	23
						Volcanic tuff	16	0*	0

*Data are of offshoots which died from basal rots.

**Data are of offshoots which died from foliar rots.

Fungicides for the prevention of basal rots. Apart from the fungicides tried for basal rot prevention detailed in Table 3, we also tried dipping offshoots in a 250-ppm solution of Milcurb once a month. Of all the fungicides examined, and of the promising ones which were tried several times, we found that basal rots were most efficiently controlled by applications of Fermate slurry (Exp. No. 2, Table 3).

Fungicides for the prevention of foliar rots. Apart from the fungicides detailed in Table 3 which were tried for foliar rot prevention, we also used the following: Actidione (100 ppm active ingredient — cycloheximide sprayed every 10 days). Of all the fungicides tried, benomyl was the

most efficient, with Vitavax a close second, in controlling foliar rots.

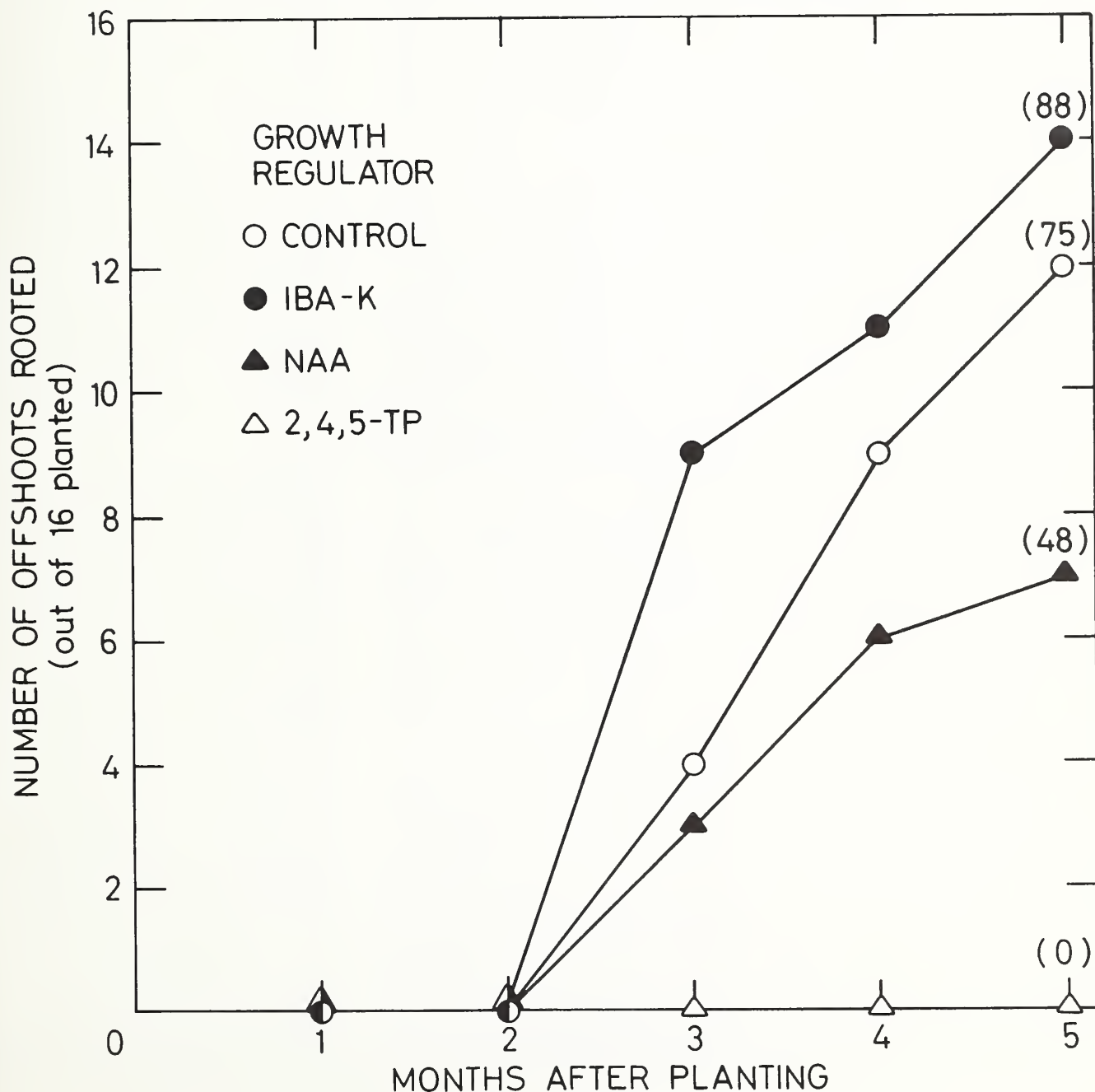
Rooting medium. Since in experiment No. 1 no differences in rooting rate were found between rooting media consisting of equal volumes of peat, Kalkar and vermiculite or equal volumes of peat and Kalkar, the latter medium was used for most subsequent experiments. The problem of very frequent occurrence of basal rots prompted us to try better-drained rooting media in the hope of reducing rot incidence. Several new media were tried, therefore, and as may be seen from Table 3 (experiment No. 4) rots were at a minimum when offshoots were planted in volcanic tuff which was the best-drained medium we used.

Root-promoting Substances:

Various substances which are known as rooting promoters were combined in the experiments described above. The substances tried and their mode of application were as follows:

- 1) Dipping offshoots for 4, 8 or 16 hours before planting, in a solution of 500 ppm NAA + 50 ppm thiamine.
- 2) Dipping offshoots for 6 hours before planting, in a solution of 900 ppm IAA + 1000 ppm IBA-K.
- 3) A monthly spray of 2,4,5-TP, at a concentration of 100 or 1000 ppm.

Figure 1 Cumulative rooting of date palm offshoots infused with growth regulators while attached to the mother palm. (Figures in parenthesis represent percentage of rooting five months after planting.)



- 4) Dipping offshoot base for 18 hours before planting, and foliage spray of 500 ppm or 1000 ppm GA₃.
- 5) Dipping offshoot base for 19 hours before planting, and foliage spray of 50 ppm 2,4-D.
- 6) Spraying offshoots with 1200 ppm or ethephon (2-chloroethyl phosphonic acid) one week before removal from the mother palm.
- 7) Infusion of offshoots with either 100 ppm IBA-K or 2000 ppm CCC after removal from the palm.
- 8) Application of Shagidol paste containing either 1% IBA-K or 2% 2,4-D to the base of offshoots.

In all treatments mentioned above except for those with IBA-K, no improvement in rooting was noted and even in the case of IBA-K, the effect was very small. There are two possible reasons why these substances are not effective: (a) the active compound does not reach the site where it is required, *i. e.*, the offshoot base, when it is sprayed on the foliage, and (b) the quantity of substance absorbed by the offshoot base when offshoots are dipped in the material is too small to be effective. Our failure to obtain better rooting, as well as other workers' negative results (23), prompted us to search for new ways of application which will ensure penetration of the substance into the offshoot. Using the infusion method which we developed, we can measure exactly the quantity of substance absorbed by the offshoot and can also control it. Offshoots which were 'infused' after removal from the palm absorbed only small quantities of the given solution and therefore did not respond. We therefore tried infusion while the offshoot was still attached to the mother palm. In this case much larger quantities were absorbed and the response to treatment was clear-cut, as shown in Fig. 1. Of all the substances tried only IBA-K increased the percentage of rooting as well as hastened it. NAA inhibited rooting and 2,4,5-TP prevented it completely. The negative response to NAA and 2,4,5-TP may have been due to unsuitable concentrations and they should be tried again before being finally rejected. IBA-K, which is an expensive compound, should also be tested again at various concentrations so that the optimum may be found.

SUMMARY AND GENERAL DISCUSSION

Small offshoots can be rooted successfully if a number of conditions are fulfilled.

a) Offshoots must be removed from the mother palm without damaging their base. The removal of a very large number of offshoots in the course of these experiments taught us that the smallest offshoot which can be removed with a hammer and chisel without damage depends on the cultivar as well as on the growing conditions prevailing in the garden. In poorly developed gardens, we could remove relatively small offshoots, weighing 2-5 kg (together with their leaves), without causing any damage. In offshoots of this size the leaves account for between one-third and one-half of the total weight.

b) To avoid death of the offshoot before it roots and becomes established, basal and

foliar rots must be controlled. The most efficient treatment for the control of basal rot was the application of a Fernate slurry to the base of the offshoot. Foliar rots can be controlled effectively by weekly sprays with 0.15% benomyl. Different concentrations of benomyl as well as different spray frequencies should be tried.

c) Rooting and rotting seem to be two antagonistic processes occurring in the offshoot. Any treatment with growth regulators which hastens the rate of rooting will also increase the percentage of offshoots which will root. We found that infusion of a 1500 ppm IBA-K solution to offshoots still attached to the palm both hastened and increased the percentage of rooting. We still have to determine the optimum concentration of IBA and the best time to infuse.

d) The rooting medium must be well drained to avoid waterlogging which increases the damage caused by basal rots.

e) The optimal temperature for the rooting medium seems to be 25°C. If the medium is unheated, offshoots should be planted at the time of year when the rooting medium is naturally at approximately 25°C.

f) Mist propagation has advantages over the commonly practiced methods of date palm propagation. The installation for this method is expensive but it has several advantages which should be carefully evaluated. Apart from the higher rate of rooting obtained, mist-propagated plants have a full complement of leaves. The rooted offshoots in our experiment were planted in 50-liter bins and after a period of hardening were removed from the mist atmosphere. They can be planted all the year round, like evergreens grown in containers. We believe that date palms planted from containers will ensure a better "take" and faster development in the garden by about two years in comparison with palms planted from a nursery or from air layering on the mother palm.

TISSUE CULTURE

The objective of this part of the project was to adapt a technique to palms which has been used successfully with a number of other plants. Tissue culture is used for plant propagation for several reasons, including the production of virus-free plants by tip culture, *e. g.* potatoes (16) and dahlias (15), and the production of a large number of plants from a limited source, as with carnations (7) and orchids (14).

The success of propagating monocotyledons through tissue culture has been limited to relatively few species, and to the best of our knowledge all of them are herbaceous, *e. g.* *Gladiolus* (33), lily (28), rice (19) and orchids (14). Even among the dicotyledons, the number of woody species successfully propagated is very small when compared with herbaceous types. In all successful cases the plant part used as the original explant was of greatest importance (25). In spite of the difficulties encountered by other workers, the technique of tissue culture was tried because of the universal interest in rapid propagation of palm species. Although much tissue culture work appears to have been done on palm species in many laboratories, very little has so far been

published. Staritzky first reported some promising results with the oil palm (29). He obtained roots on small blocks of trunk tissue, and feathered or juvenile-like lanceolate leaves on explanted "growing tips."

Although no dormant buds exist in the axils of mature date palm leaves, there are 100-120 primordial leaves and buds between the spike leaf and the apical meristem (9). Much of the work in this project was directed at finding ways of culturing these buds and forming new plants from them.

A second technique attempted was the culture of meristematic tissue with a view to differentiating new plants from it. A method of embryo culture was developed. The germinating embryos and resulting seedlings were used to test nutrient media, supplements to these media, environmental culture conditions and work techniques. It was thought that results from work with the embryos could be applied to other tissues and organs.

MATERIALS AND METHODS

The organs and tissues used in the many cultures attempted included buds, tips, (which consisted of the apical meristem and many primordial leaves surrounding it), mantle meristem, primordial leaves, tissue-removed leaf bases and leaf sections — all taken from young offshoots; sections cut from young seedlings; cotyledonary sheath sections and growing points taken from *in vitro*-germinated seedlings; whole embryos; fruit stalk, ovaries, unfertilized ovules and partheno-genetic endosperm; and roots.

We shall not describe all the work done in detail, since a full report will be published elsewhere, but will give a general summary of the main results. In every case, the tissue or organ used was surface-disinfected and the internal parts taken for culture were then removed under aseptic conditions.

Different nutrient media developed by the following research workers were tried: White (31), Murashige and Skoog (17), Linsmaier and Skoog (12), Murashige and Tucker (18), Letham (11), Miller (13), Nitsch (20), Lavee (10), Reinert and Mohr (26), Hackett and Anderson (7). Different supplements were added to some of these media. These included: plant growth regulators (auxins, cytokinins, gibberellin); organic extracts (of yeast, malt, peas, date palm seeds, and pollen); and other substances (casein hydrolysate, corn hydrolysate, coconut milk and date palm exudate). Cultures were grown in temperature, humidity and light controlled rooms.

RESULTS AND DISCUSSION

Media used by other people for a very large number of species were tried in the hope of finding suitable combinations for our purpose. The only plant part which survived, developed satisfactorily, and responded to treatments, was the young seedling grown from *in vitro*-germinated embryos. When the same media were tried with other tissues, the latter did not respond with the same satisfactory growth. This emphasizes the fact that not only do different species have different requirements, but tissues from the same species may well vary in their nutrient and growth factor requirements.

Although we did not succeed in using this technique for propagation, we occasionally obtained some development. Large differentiated buds and growing tips generally produced an initial flush of growth consisting of a considerable expansion of leaves which often greened. This development ceased after a couple of months when the surface of the explant and the medium browned. Callus occasionally formed on the cut surface of trunk tissue or primordial leaf bases. Roots developed on a number of tips and buds but eventually the "plantlet" died. Callus which had developed from the cotyledonary sheath of *in vitro*-germinated embryos, proliferated masses of callus when transferred together with a piece of the cotyledon. The same occurred with roots which arose from the cotyledonary sheath under the influence of NAA. (This is a tissue which under normal conditions does not produce roots).

The occasional rooting of buds, tips and primordial leaves did not happen as a clear response to our treatment and we were unable to reproduce it. It seems, therefore, that the potential for regeneration which apparently exists in these organs and in other tissues included in the study, was generally not expressed in our cultures. With annual monocotyledons, where new plantlets have been produced successfully, the source of explant seems to have been of critical importance (28, 32, 33). Citrus is one of the few examples of a woody plant successfully propagated which could only be regenerated from the nucellus and not from other tissues (25). It therefore seems worthwhile to try again with different types of explant taken from palms of different ages. An explant coming from a very young offshoot may have a higher potential for regeneration than others.

A serious problem which we encountered throughout our work and which will have to be studied in greater detail is the browning of all tissues and organs (except for embryos) in culture. Since the darkening was assumed to be due to the oxidation of polyphenols present in the tissue, different substances were tried to prevent it. Of these, ascorbic acid, polyvinyl pyrrolidone (PVP) and dihydroxynaphthalene were ineffective. The addition of activated charcoal to liquid media, which was found to be a promising treatment, proved to be effective only for a limited period. After one or two transfers the nutrient medium browned and tissues ceased growing.

Another finding which is worth further attention is the callus and root development from the cotyledonary sheath tissue of embryos germinated *in vitro* and growing in the presence of NAA. This callus continued proliferating and differentiated roots when subcultured if a piece of the cotyledonary sheath was present. It seems that the cotyledonary sheath contains rooting co-factors as well as some other substance which enables callus and possibly other palm tissues to grow.

SUMMARY

The aim of this study was to develop a new and rapid vegetative method for the propagation of date palms. Three main lines of research were followed:

1. Rejuvenation of Mature Palms

Various treatment aimed at renewing the production of offshoots were given to mature palms; none of the treatments gave positive results.

2. Rooting of Small Offshoots

Progress was achieved in rooting small high offshoots under mist. The best results were obtained when offshoots were infused with the potassium salt of indole butyric acid before removal from the mother palm. Serious rotting was very prevalent under mist propagation. This can be prevented by treating the base of the offshoot with a slurry of the fungicide Fermate before planting, and spraying the foliage with the systemic fungicide benomyl once a week.

The endogenous differences between difficult-to-root offshoots (high and small) and easy-to-root ones (large and low) were studied. The carbohydrate content of easy-to-root offshoots was found to be higher than that of the difficult-to-root ones, whereas the opposite was true of the rooting inhibitor content. The latter was assayed by the Mung bean rooting test.

3. Tissue Culture

Many attempts were made to culture date palm tissue *in vitro*; of the various tissues and organs tried, only embryos could be cultured successfully. Nutrient media found suitable for embryos were unsuitable for other tissues. "Tips" rooted in certain cases, but this was generally at the expense of the original explant and no further development occurred. Callus was occasionally produced by certain "tips," but could not be subcultured.

The common factor found in all tissues and all media tried was the discharge of a yellowish-brown compound into the medium; this substance inhibited the development of the tissues. A method for preventing its accumulation was found. Tissues did not die but continued developing when activated charcoal was added to liquid nutrient media. This was a temporary effect and development ceased after a while.

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